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TELEPLOT - A METHOD OF TRANSMITTING PICTORIAL DATA BY TELETYPE

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TELEPLOT

A METHOD OF TRANSMITTING PICTORIAL DATA BY TELETYPE

by

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1. INTRODUCTION

1.1 TELEPLOT Method

TELEPLOT is a method of transmitting pre-plotted meteorological, oceanographic, or scientific data by radioteletype. The method can be applied now, and the possibilities of further sophistication into the transmission of complex computer products to all levels of the Navy indicate its value as an operational tool. Any facility, ship, or unit with a radioteletype can receive computer products, environmental data (plotted and/or analyzed), or any data which can be positioned, isoplethed, or graphed by TELEPLOT. Like any teletype message, it can be encrypted for security.

1.2 Background

The principle of transmitting pictorial or prearranged data by teletype is not entirely new or untried. The Weather Bureau had some success with this method in the early 1900's, when air routes and weather observing stations were few and far between. As the number of stations increased, the communications networks rapidly became saturated. Blank spaces on a weather message became a sinful waste, because each blank space took as much time as a letter or digit and transmitted no information. (In this sense, the teletypewriter has not improved since its invention. It still has a single space advance rather than a multi-space tabulator.) The available circuits did not expand as rapidly as the data volume, and, as the prearranged pictorial data were also laboriously done by hand, they disappeared from the networks.

Many observation reports were sent by Western Union, which charged for the

service by the number of words. By agreement, 5 digits were designated as one word. In the interest of economy, a complex coding system was developed so that a single digit could replace several sentences. Each digit in each 5-digit group represented a different environmental phenomena. The same 5-digit system is used today.

The Weather Bureau, Army, Air Force, and Navy have made several attempts to develop a usable method of transmitting pictorial or graphic information by teletype. The author experimented with a manual system for sending local weather data in map form by radioteletype between the weather office of NAS, Jacksonville, Florida and an aircraft carrier in the Jacksonville Fleet Operating area in 1962. The method showed considerable promise but disappeared when the trained air station communications personnel were transferred; shortly thereafter, the author was also transferred.

1.3 Recent Developments

The communications system has changed from a single network concept to a centralized collection and a decentralized distribution system. Whatever is done at the distribution points is independent of the centralized collection system. The requirement for maintaining the 5-digit grouping of environmental data does not apply to distribution points, particularly Navy radio-teletype distribution points.

Computers have changed the environmental data concepts considerably. Derivations that were impossible on a real-time basis years ago are now available in profusion. Data voids can be filled with computer extrapolations. However, transmitting these data to the ship and facility user in a comprehensible form in time to

be operationally usable is now a major problem.

In May 1966, the U. S. Navy Weather Research Facility developed experimental routines for the Raytheon 440 computer so that it would rearrange surface synoptic weather observations into a preplotted weather map format. The computer produced a teletype tape of this rearranged data so that, if the data were transmitted, any ship or facility would receive a plotted weather map from their teletypewriter. Since the receiving teletypewriter was doing all the plotting, the method was named TELEPLOT for TELEtypewriter PLOTting.

In July 1966 the U. S. Navy Fleet Weather Facility, Norfolk, Va. began using this method to send High Seas and Wind Warning charts, subsequently followed by Sea Surface Temperature, Sonic Layer Depth, and Surface Pressure Pattern charts under the name of RATTGRAPHICs. The TELEPLOT/RATTGRAPHIC charts fulfilled a basic requirement of the ship officers to receive intelligence quickly and in an immediately usable form without ambiguity. Based on letters and conference reports, this method has been almost universally acclaimed as a major improvement over the verbal message format. The Fleet Weather Facility and the Weather Research Facility are continuing to develop more sophisticated TELEPLOT/RATTGRAPHIC charts in response to fleet as well as research requirements.

2. THE PROBLEMS

A primary function of the Naval Weather Service is to provide the fleet with operational meteorological and oceanographic data, descriptions, and forecasts. Bringing the results of new research and development in the environmental fields to bear on Navy operational requirements is a continually expanding problem. Even after the research and development problems have been solved, they have little value to the fleet if they cannot be applied in a time frame that is usable in a particular operation. The historical approach has been to add these data to the facsimile and radio-teletype schedules in a standardized alpha-numerical format. The result has been a decrease in efficiency. The analyst-forecaster is faced with an ever-increasing amount of data which is largely unrelated to his particular problems or his area of operations. Not only is this a waste of valuable communications time, but, once received, the data must be laboriously sorted to separate the applicable data from that which is useless to the forecaster's application.

As the results of research and development in the environmental fields increase in complexity, the products are aimed more and more at the ships and facilities with larger staffs of environmental personnel. Although the problems of the ships without meteorological personnel have not been forgotten, they have not been emphasized.

In a simplified manner the problems are:

A. Making computer products available to the fleet in an operational time frame;

B. Eliminating the data which does not apply to the Navy, or a particular

area of Navy operations;

C. Increasing the usability of the products, so that the time from observation to briefing is reduced;

D. Including products that are directly usable by ships which do not have facsimile equipment, nor meteorological personnel aboard.

All of the above can be done by utilizing the Navy Weather Centrals and Facilities as data filters, producers, rearrangers and distribution points.

3. THE PRINCIPLES OF THE TELEPLOT METHODS

3.1 Manual Method

The basic principles of TELEPLOT are very simple. To illustrate, select a section of an analyzed weather chart, graph, or any page with one or more slanted or curved lines. Place a sheet of tracing paper over this data sheet and put both in a typewriter. Using a pre-designated digit code for the values on the data sheet, type the appropriate digit over each line as it appears in the typing position. When there are no more data lines to the right, space to the next line and repeat the process for subsequent lines until there are no more data lines, or until the page is completed. When the papers are removed from the typewriter, the tracing paper will represent a TELEPLOT. If the above process had been done on a tape cutting teletypewriter, it would have produced a TELEPLOT teletype tape. Transmitting this tape would produce a TELEPLOT at any receiving ship or facility which would be a duplicate of the data on the tracing paper. Reconstructing the original data from the TELEPLOT is a simple matter of connecting the data digits with faired lines. Note that no plotting is required by the receiver.

3.2 Digitizer Method

This hand method, as mentioned above, can be used by facilities or ships which have only an occasional need for sending a TELEPLOT. A weather central or facility would normally require a digitizer similar to the one in use at the Fleet Weather Facility, Norfolk, Va. They use the Benson-Lehner LARR-V Digitizer, which simplifies and accelerates the transfer of data from an analyzed or forecast chart to teletype tape. The principle is straightforward. The data

chart is affixed to the large chart table. An arm, which extends from the top to the bottom of the chart board, is connected electronically to a magnetic tape recorder. The arm moves right and left, with its position continually sensed electronically. On the arm is a carriage with a recording stylus, which moves in a vertical plane across the chart table. To prepare a TELEPLOT/RATTGRAPHIC, we place a gridded overlay on top of the analyzed chart, and the stylus is positioned over the first isopleth (line). The recording button is then depressed and the position (horizontally and vertically) as sensed by the position of the arm and the carriage, is recorded on the magnetic tape. The same isopleth is followed along the chart, depressing the record button once in each grid, which corresponds to the spacing on the teletypewriter. After the data for the first isopleth has been recorded, the value of the isopleth is changed on the digitizer, and the subsequent isopleths are recorded. The digitizer magnetic tape is then placed in a computer and from an established program, a teletype tape is cut. The teletype tape is then transmitted, and the receiving ship or facility receives a completely plotted chart, or a TELEPLOT/RATTGRAPHIC, from the teletypewriter.

In its simplest form, only one parameter, such as sea height or wind speed, is TELEPLOTted; however, several parameters can be sent for each grid point in the form of a data block. Quite often this is advantageous, particularly in meteorology, where several values have to be mentally integrated with the parameter that is actually being line analyzed (isoplethed) on the chart.

3.3 TELEPLOT Versatility

The degree of definition of the data on a TELEPLOT is a function of the scale

of the chart. The physical limitations of data are imposed by the width of the teletypewriter paper (69 spaces), but data could be sent in more than one section and joined by benchmarks at the receiving ship or facility to increase the width. A well-designed TELEPLOT should be able to replace at least one of the less comprehensible forms of weather data presently in use; hopefully, it can replace several. Figures 3.1, 3.2, and 3.3 demonstrate the change in data definition with the change in map chart scale and the wide versatility of the method. In the figures, the land areas are marked with slants (/) and sea surface temperatures are in degrees fahrenheit with the tens digit omitted except at the ends of the isotherm.

ATLANTIC SEA SURFACE TEMPERATURE APRIL

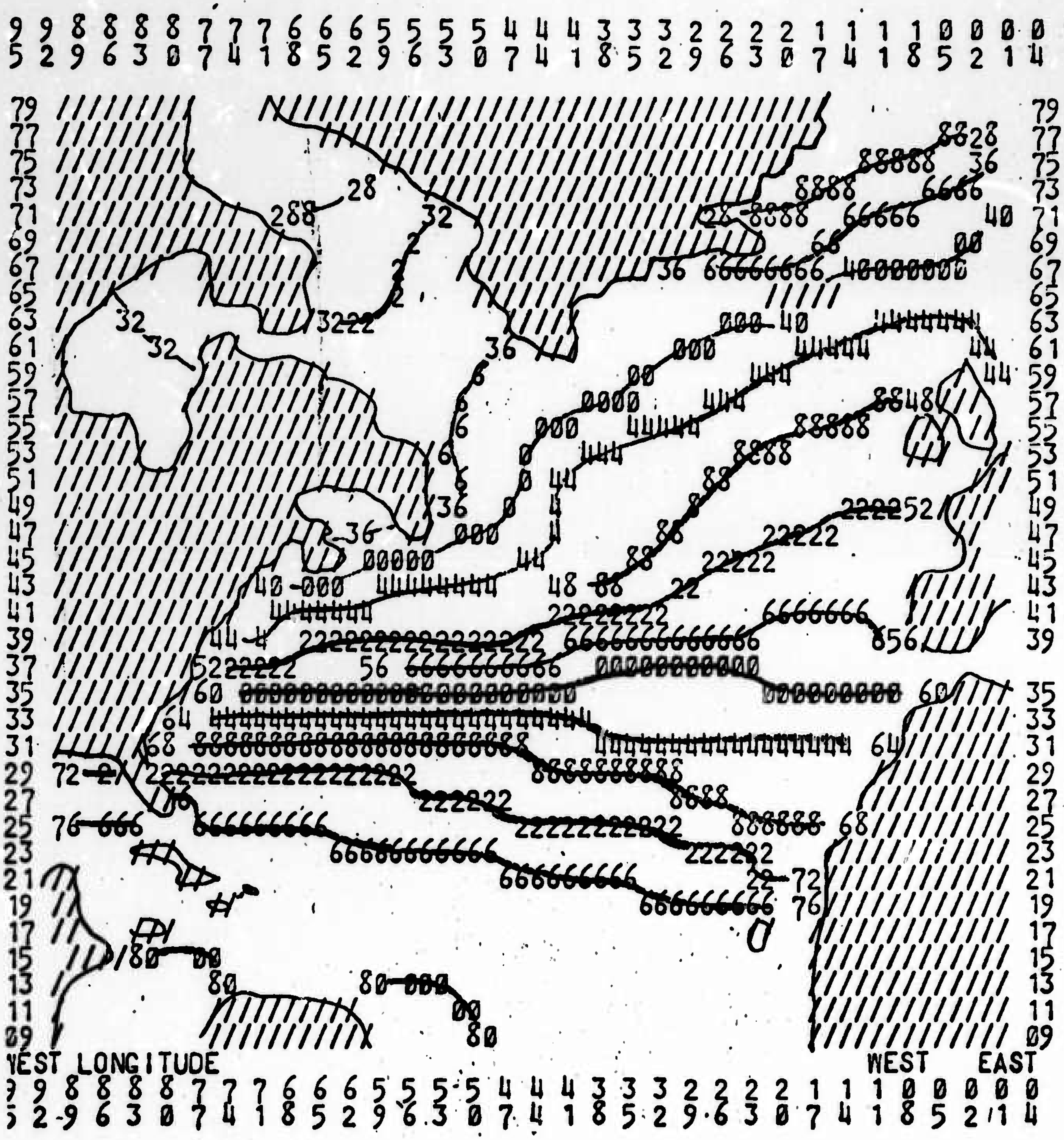


Figure 3.1. Sea Surface Temperature, North Atlantic in April. Land area depicted by slants. SST in degrees Fahrenheit.

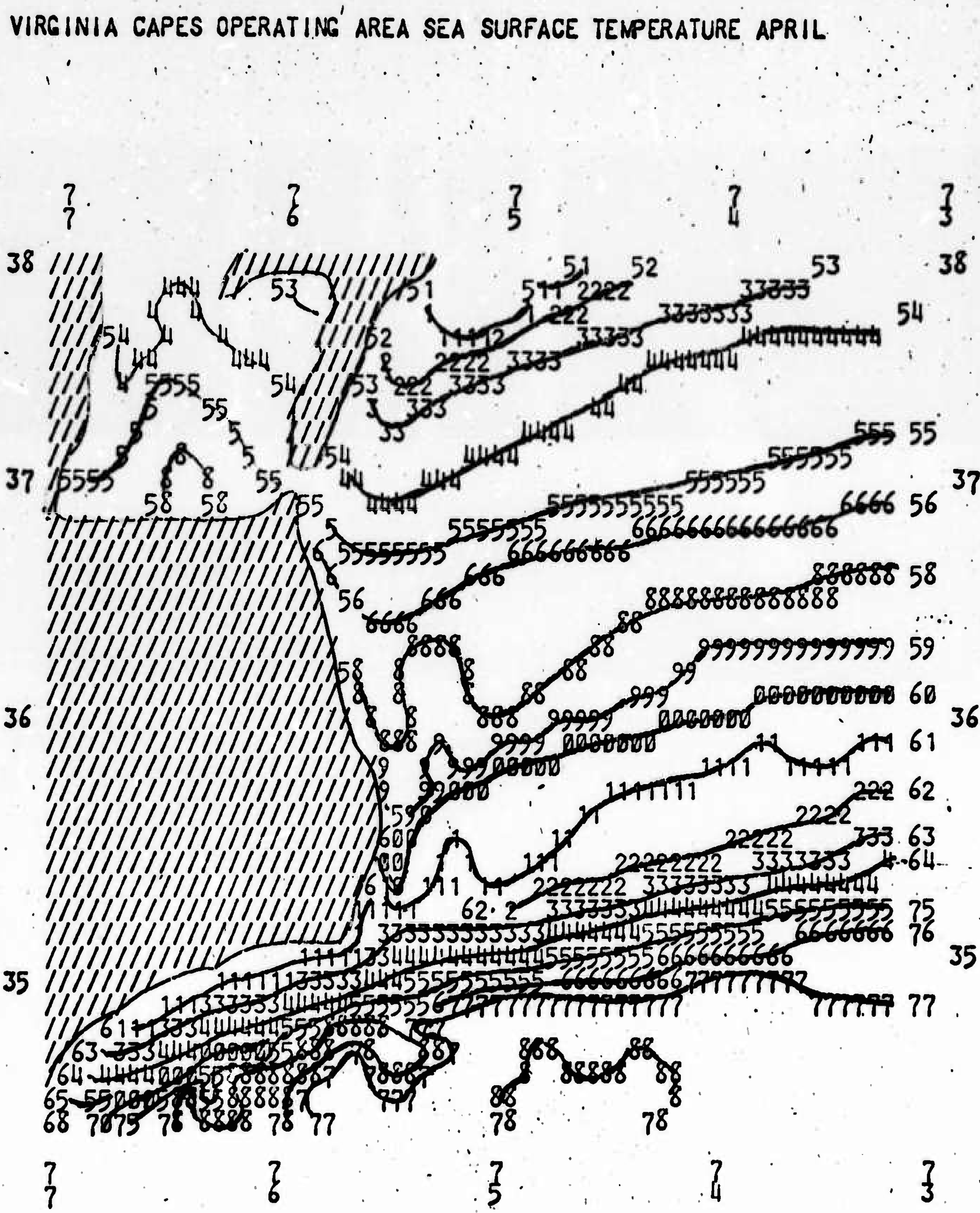


Figure 3.2. Sea Surface Temperature, Virginia Capes Operating Area in April. Land areas depicted by slants. SST in degrees Fahrenheit.

HAMPTON ROADS SEA SURFACE TEMPERTURE APRIL

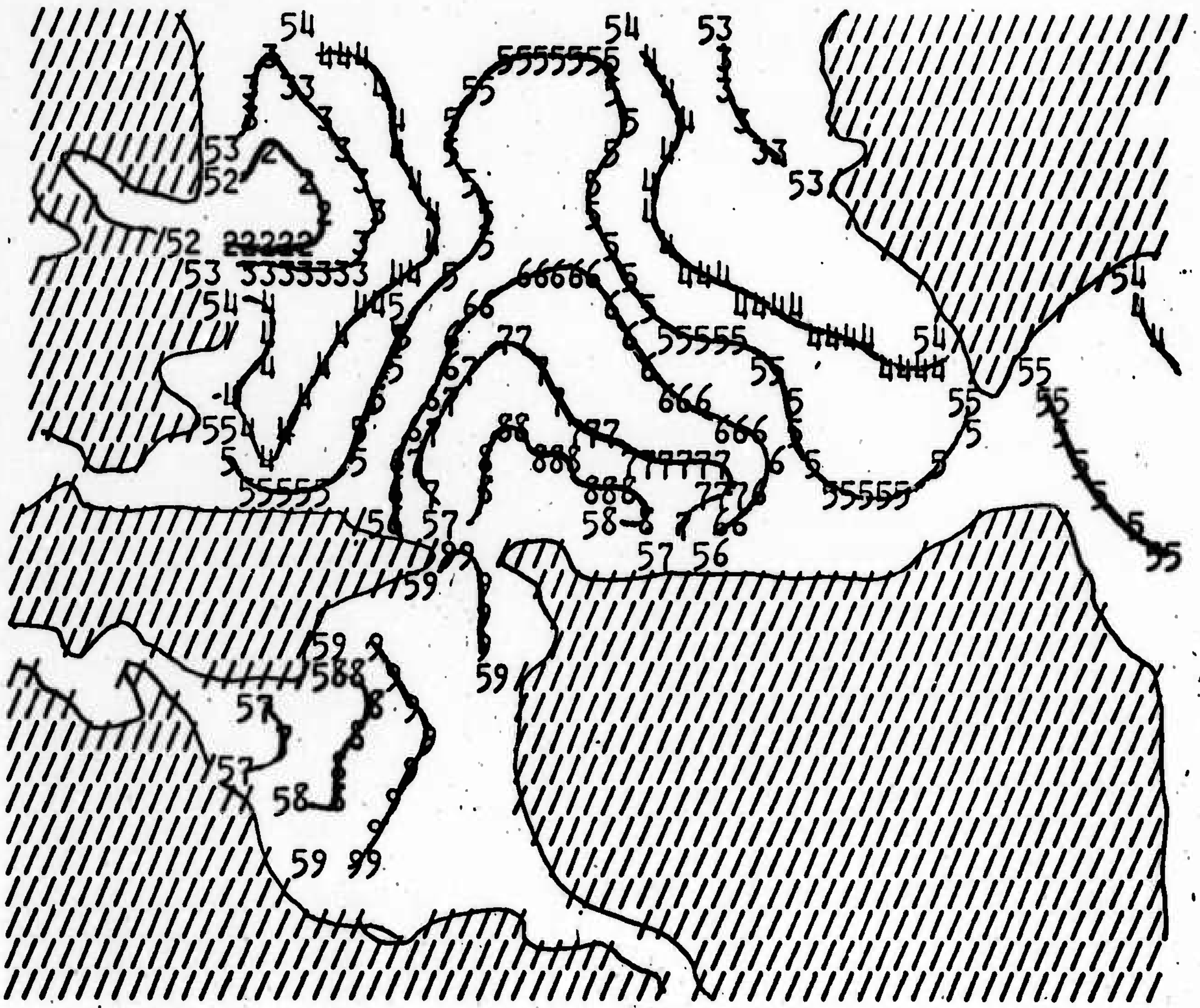


Figure 3.3. Sea S[illegible] Temperature, Hampton Roads [illegible] area [illegible] SST [illegible]

4. PRINCIPLES OF DATA ARRANGEMENT FOR TELEPLOT

There are several principles to data comprehension and arrangement which were applied in developing these TELEPLOTs. They should prove helpful in developing TELEPLOTs locally or in modifying those included in this report.

A. Code forms. Wherever possible, use World Meteorological Organization (WMO) code forms currently in use. This decreases the learning time in data rearrangements.

B. Data placement. The eye is more sensitive to digits at the beginning or ending of a data group. Therefore, important data in a single or double line grouping should be at the beginning or end of a line. If the grouping is three or more lines (a data block), the key groups should be at the corners of the data block. If the key data is plotted in this manner, the analyst can scan the page for salient features before a more formal analysis is started.

C. First priority data. If it is too lengthy or if, for some other reason, it cannot be conveniently placed at the corners of a data block, first priority data should be placed at the top of the data block with the highest priority item at the left.

D. Data for isoplething. The data should be located as close as possible to the center of the data block. The natural tendency is to use the center of a grouping for the reference point.

E. Addition or subtraction of data. Operation is facilitated if the data is arranged in a vertical column at either side of the data block, preferably the

left side, e.g., t t
t_d t_d
t_s t_s

F. Logical grouping of data. Clouds, pressure, temperature factors, etc., should be grouped together to allow easy mental integration.

G. Factoring. Data should be factored to reduce it to the smallest number of message digits consistent with the degree of accuracy required, e.g., 5,000 ft. ÷ 100 = 50 (code figure) 10,000 yards ÷ 1000 = 10 (code figure), 21 feet ÷ 3 = 7 (code figure). Factoring of data ranges is another approach when both sender and receiver have access to the same table of values.

2.5937 - 2.7543 = 1

2.7543 - 3.0001 = 2, etc.

H. Data progressions or limits. They should follow customary concepts and training as closely as possible. There is little chance of error if the base and top of a phenomena are described by altitude at the beginning and end of a data group; e.g., $h_b h_b N h_t h_t$, 25650. The layer in question, defined by the code digit 6, extends from 2,500 to 5,000 feet.

I. Numbers versus letters. Shifting from upper to lower case and vice versa on the teletypewriter introduces another possibility of garbling and should be avoided if the understanding of the message is not impaired by using all digits. Moreover, letters usually have to be transposed back to digits before they can be used, thereby delaying the use of the information by the receiver.

5. THE ECONOMICS OF THE TELEPLOT METHOD

Prior to July 1966, the Navy had one system for the transmission of pictorial or graphic environmental data to ships at sea and small facilities -- the facsimile recorder. With this equipment in peak condition and under the proper atmospheric conditions, reproductions of weather charts and other data can be received by radio. But with only a small number of facsimile recorders aboard ship or a small air station, the somewhat temperamental recorders rarely reach the peak condition. The tuning of the radio signal for facsimile is quite precise, and, if the receiver is on a ship moving through continually changing field strengths, tuning is a nearly continuous job in order to receive the best signal.

At present, the facsimile broadcast cannot be encrypted and might necessarily be silenced during wartime conditions. The Navy needs more than one system with which to communicate pictorial or graphic data. Preferably this system should be encryptable, reliable under a wide range of conditions, able to present data in a variety of easily readible forms, and versatile enough to fulfill a large percentage of user requirements. The radio-teletypewriter using the TELEPLOT method fulfills these conditions.

The TELEPLOT method is designed for the operational user in a limited operational area, although it could be used to improve the general weather broadcasts. The present general broadcast does not completely fulfill Navy requirements under the best conditions, and, under more or less normal conditions, the broadcasts are quite often inadequate. Under wartime conditions, the situation may be expected to deteriorate even further. The spectrum of TELEPLOTs

presented in this paper should not be considered complete; developments are continuing on more sophisticated products. However, the TELEPLOTs as presented here could serve a wide variety of users with unique Navy and military problems, who are not being served now, or who are being served inadequately. TELEPLOT, by being preplotted and, in some cases, preanalyzed, provides environmental data to the ships without meteorological personnel. As the data is preplotted it can be used almost immediately without the laborious and occasionally ambiguous decoding of data, and without introducing the chance of error from erroneous plotting.

Aboard ship, time, space, and trained personnel are premium commodities. The TELEPLOT method, by directing the data toward a specific operational problem in a specific operational area, eliminates the requirement for copying radio-teletype data continuously. Data that is not usable to the fleet has been filtered out at the central and facility level. Data that is not now available to the fleet, where there are fleet requirements, can be computer-generated at the centrals and facilities; e.g., oceanic cross-sections and data grids, refractive index charts, sea, swell, and surf charts, etc. These data can be transmitted by the TELEPLOT method. The elimination of data not useful to the Navy will provide more than sufficient communications time for new Navy-oriented TELEPLOTs. The more general TELEPLOTs are designed to replace one or more of the present data schedules in at least a comparable amount of communications time.

Comparing the time that it takes for a teletypewriter to print two pages of the same length under the present system versus the TELEPLOT method is unrealistic. First, the time required for the computer to sort, compute, and position the data,

short though it may be, must be considered. When it is received, the time to prepare a chart for analysis must also be considered. The TELEPLOT is ready for analysis as soon as the message is complete. With the present system, the data for a surface chart of an area is received in bits and pieces, interspersed with route and terminal forecasts, data from other sections of the country, and sometimes NOTAMS. After the data are received, a plotter decodes the data and plots the information on a blank weather chart. A true measure of the time used in an environmental system must be the time measured from the observation to the briefing; all other steps are incidental.

Since the data is received from the teletypewriter in preplotted and largely precomputed form, the requirement for data plotters (four or five men on a four-section watch bill) has been eliminated.

In addition to the four or five berthing spaces saved, the TELEPLOT data storage space is considerably less. Assuming that, on the average, a ship requires 2 surface weather TELEPLOTs each 6 hours; that is 8, 8 x 11 pages a day, or 2,920 pages a year, roughly a stack of paper 13 inches high. There is little comparison between this and the 28" x 46" trimmed weather charts currently in use.

The TELEPLOT method offers procedures for decreasing:

1. The time required from data receipt to briefing, by eliminating the requirement of plotting;
2. The number of personnel required to man an environmental detachment office;

3. The possibility of error, because the data is used in the same form as it is received;

4. The amount of teletype copy that must be received by any one station or ship;

5. The amount of storage required, because the amount of teletype copy is decreased, and the received copy is also the weather map.

This method offers ways of increasing:

1. The time available to a forecaster;

2. The concentration on regional weather;

3. The forecaster's four-dimensional concept of the weather;

4. The efficiency of the environmental detachment offices by decreasing the large volume of data of limited or no value to Navy operations;

5. The neatness and accuracy; i.e., the plot is typed.

6. The ease of handling the briefing maps (aids) in a handy, regional TELE-PLOT size.

The present teletypewriter machinery is set for a single-space advance, whether the space is blank or contains a character. These machines could be improved if there were a means to transmit a multiple space; for instance, a five-space tabulator, rather than a single-space advance.

APPENDIX A

OPERATIONAL APPLICATIONS TO A UNIT WITHOUT ENVIRONMENTAL DETACHMENT AUGMENTATION

1. Definition

For the purposes of this report, a unit without environmental detachment augmentation is defined as a unit without meteorological personnel aboard and with a radio-teletypewriter system, but not a facsimile receiver or recorder. Percentage-wise this represents a major portion of the armed forces. To illustrate some of the advantages of TELEPLOT, it will be applied to a few fictitious operational problems.

2. The TELEPLOT Code and Format Manual

The next logical development of the TELEPLOT method would be a manual with the various codes and formats for all conceivable parameters, clearly catalogued and explained. With such a manual, the sender could simply select the format most adaptable to his needs and reference the selection in the message heading. The receiver would refer to the manual for a complete explanation of the codes and format.

3. AO En Route Newport, R. I. to Gibraltar

The commanding officer of the AO has been ordered to proceed from Newport, R. I. to join the SIXTH Fleet in the Mediterranean, refueling an ASW exercise group northwest of Bermuda en route. He requests weather information and forecasts along his route from the Fleet Weather Facility, Norfolk, Va.

From the TELEPLOT Code and Format Manual, the forecaster at FWF, Norfolk selects the following format:

$$
\begin{array}{lll}
Lo & & {}^{Lo}/_{La} \\
 & ddffW_1 & \\
 & d_wd_wP_wH_wV & \\
 & d_sd_sP_sH_s & \\
 & & La
\end{array}
$$

Where:

Lo - Longitude, whole degrees.

La - Latitude, whole degrees.

dd - Wind direction in tens of degrees.

ff - Wind speed in knots.

W_1 - Forecast weather, WMO Code 4562.

d_wd_w - Direction from which waves are coming WMO Code 0885.

P_w - Period of the waves, WMO Code 3155.

H_w - Height of the waves, WMO Code 1555.

V - Visibility at the surface, WMO Code 4300.

Sea and swell are combined unless both are significantly high for the type of ship in question and are coming from different directions (greater than 30° difference). If the swell is forecast to be significantly different, the swell group $d_sd_sP_sH_s$ would be added to the data block.

C - Cold front.

W - Warm front.

Under normal weather conditions, the weather forecast would be sent as four one-degree areas. The four one-degree forecast data blocks should be positioned

so that the data will represent the area through which the ship will pass during the forecast period. At times it might be prudent to expand the forecast area to nine data blocks or to show more definition by shifting to half degree data blocks. This can be done at the facility without any exchange of messages by simply changing the Lo/La to degree of definition desired.

With the addition of the warm fronts (W) and cold fronts (C) to show the position of the fronts, the TELEPLOT becomes a small regional weather map. By plotting the position of his ship and the ASW exercise group right on the TELEPLOT message, the commanding officer of the AO can see the forecast weather hazards and sea conditions and may then decide on the best refueling course, or on a change of the rendezvous area, should it be advisable because of weather conditions.

4. The ASW Problem

Obviously all ships in the Navy cannot be outfitted with computers. Even if the economy could finance such a program, many ships would not have the space or the personnel to maintain such complex equipment. Moreover, every ship could not justify the use of such equipment. However, operational control centers and weather centrals or facilities with computers could transmit complex computer derivations, as well as sea surface temperatures, sonic layer depths, or salinity charts by TELEPLOT. Any ship or facility with a radioteletypewriter could receive computer information by these methods. This information would assist destroyer and helicopter groups in determining the best depth for their sonar gear to detect submarines. The submarines could receive data which would assist them in avoid-

ing detection, and the surface ships would be able to determine the best routes to avoid detection by the submarines.

The TELEPLOT method seems particularly appropriate for the ASW field, as well as aviation, which will be discussed in a later section. As an illustration, consider a computer derivation of certain properties of sound based on the inputs of bathythermographs or, for that matter, based on computer forecast data. TELEPLOT is adaptable to factoring procedures to reduce the size or complexity of the numerals and shorten the messages involved. A page from the TELEPLOT Code and Format Manual would be similar to this for a sound problem.

Parameter	Factor	TELEPLOT
Distance	1000 yards	S
Depth	100 feet	D
Intensity	Decibels	I

Format.

	S	S	S	S	S
D	I	I	I	I	I
D	I	I	I	I	I
D	I	I	I	I	I
D	I	I	I	I	I
D	I	I	I	I	I

Example TELEPLOT Message Body

	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6
1	9	6	1			1	5	5	5	4	4	4	2	1		
2	8	9	6	1	1	4	5	3	2	1	2	3	3	3	3	1
3	6	8	8	5	4	6	3	1			1	2	3	3	5	3
4	1	8	8	6	6	4	1		1	2	2	4	4	2	1	1
5	1	6	7	7	5	2		2	4	5	4	3	2	1		
6		3	6	7	6	2	4	5	5	5	3	1	1			
7		1	4	6	6	5	6	5	5	2	1					
8		1	3	6	8	8	5	2								
9		1	2	5	8	8	2									
0																

The analyzed expanded reproduction for operational use on the ship or submarine is illustrated in figure A. 1.

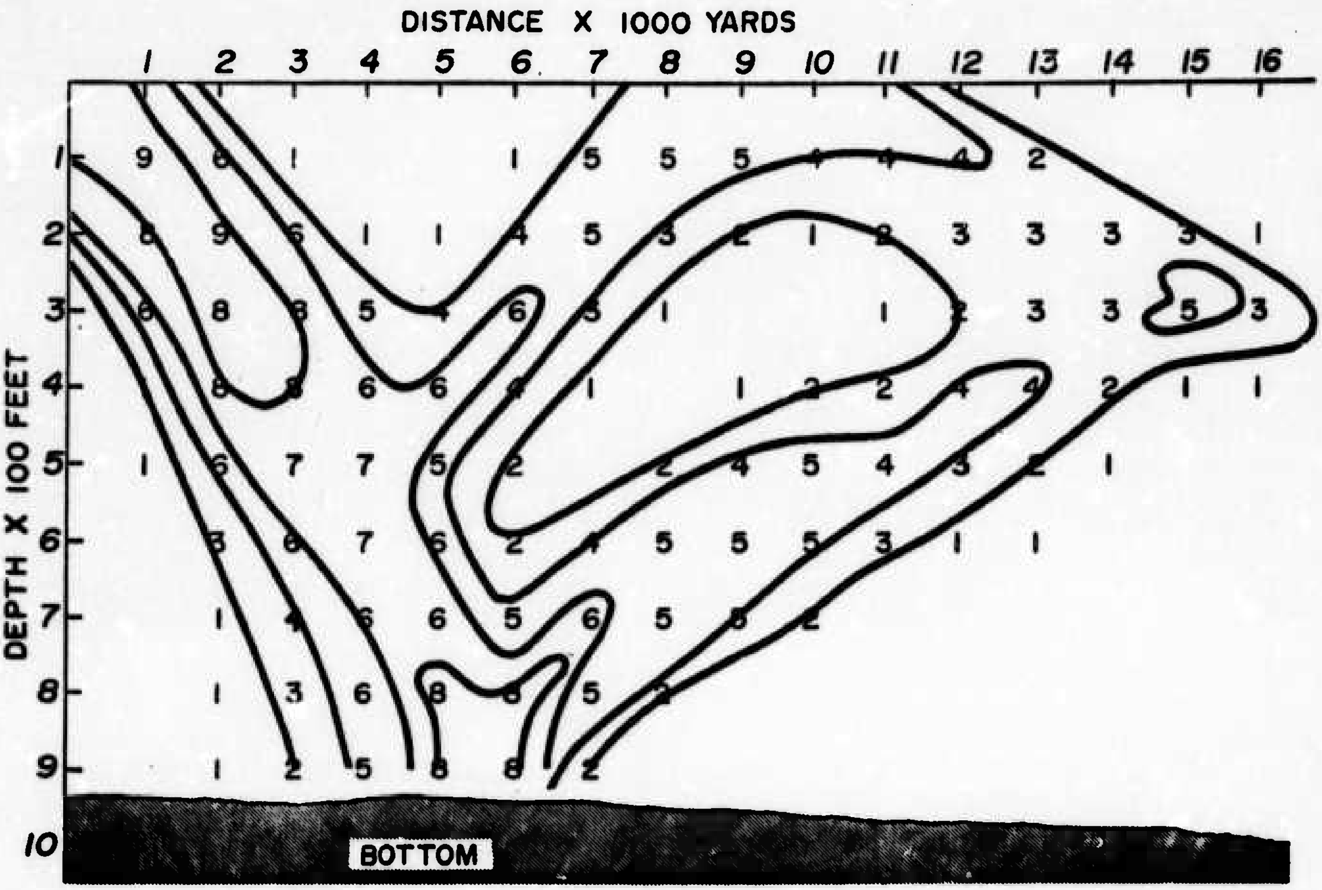


Figure A.1. Example sound problem expanded from TELEPLOT message format to operational graph.

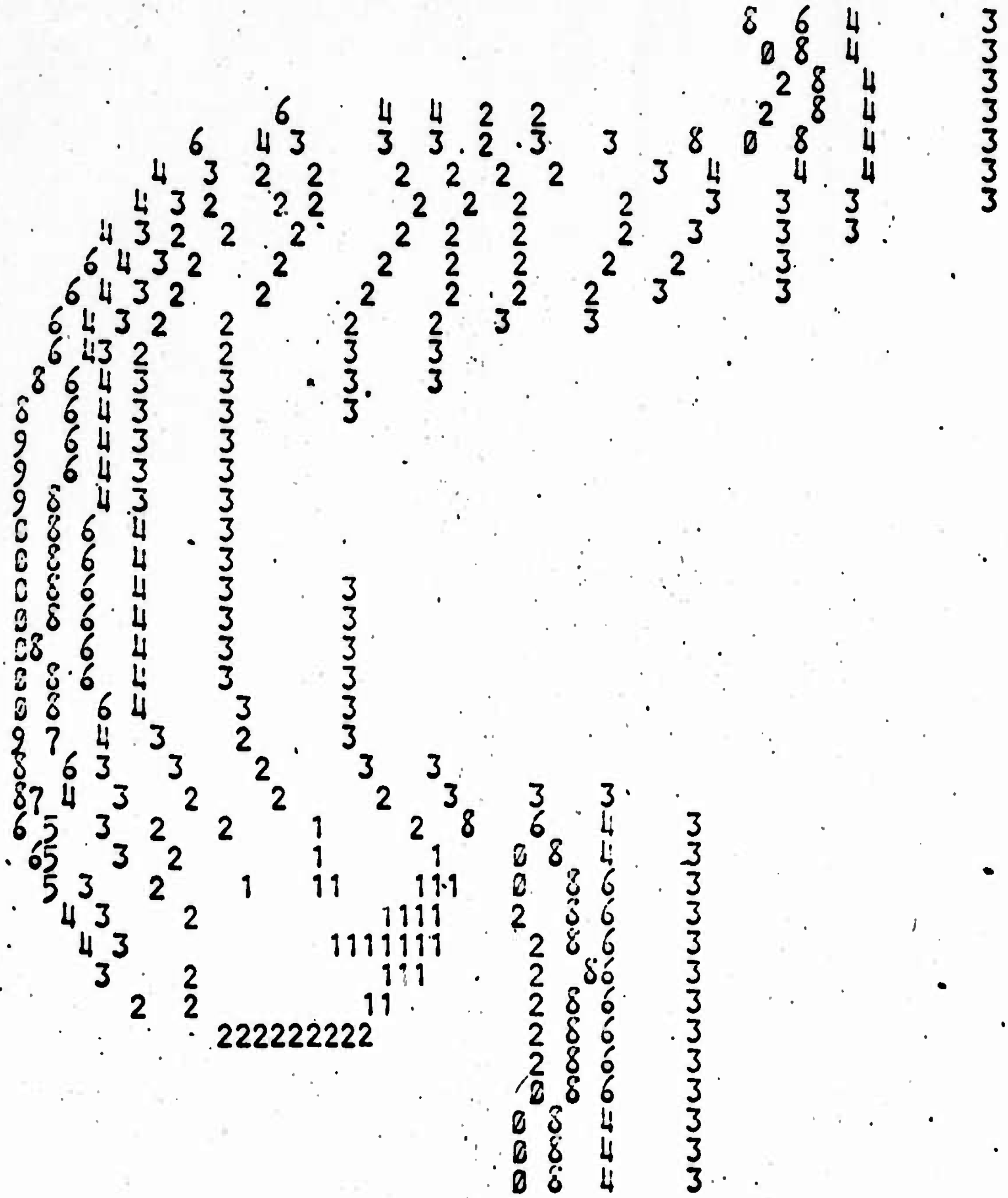
5. Amphibious Operations

The more obvious TELEPLOTs for this type of operation would be weather, sea, swell, and surf. The latter makes a very interesting TELEPLOT. A few years ago the directional rays of the surf, the wave fronts, refraction as the waves shoal, breaker type and height were all laboriously hand computed, now they can be programmed through the computer in a small fraction of the time, and now TELEPLOT can make these computer derivations available to the fleet, figure A. 2.

Figure A. 3 is the analysis of the Sea and Surf TELEPLOT. This TELEPLOT is designed to fit over some chart common to all users. Bench marks or latitude, which has been omitted on this example, would be used for aligning the TELEPLOT with the base chart. The numbers represent the heights of the sea and surf. By connecting the lines of numbers together with faired lines, as was done in this figure, the orientation of the wave fronts and orthoganals can be determined. At either point and at the center of the beach, notice that the height of the breakers increases to 10 feet and above but that the tens digit is omitted.

It should be emphasized that TELEPLOT is a two way exchange of intelligence. It can be used just as easily to transmit data from the fleet to the computer center, or for that matter, ship to ship. To illustrate, an underwater demolition team (UDT) surveys a shoreline in preparation for an amphibious assault. The collected data, beach gradient, water depths, currents, natural and man-made obstructions, mine fields, etc. can all be plotted on a chart and sent to the Amphibious Strike Force Commander by TELEPLOT. TELEPLOT data can easily be

Figure A.2. Sea and Surf TELEPLOT for overlay onto a navigational chart. Latitude and longitude benchmarks omitted.



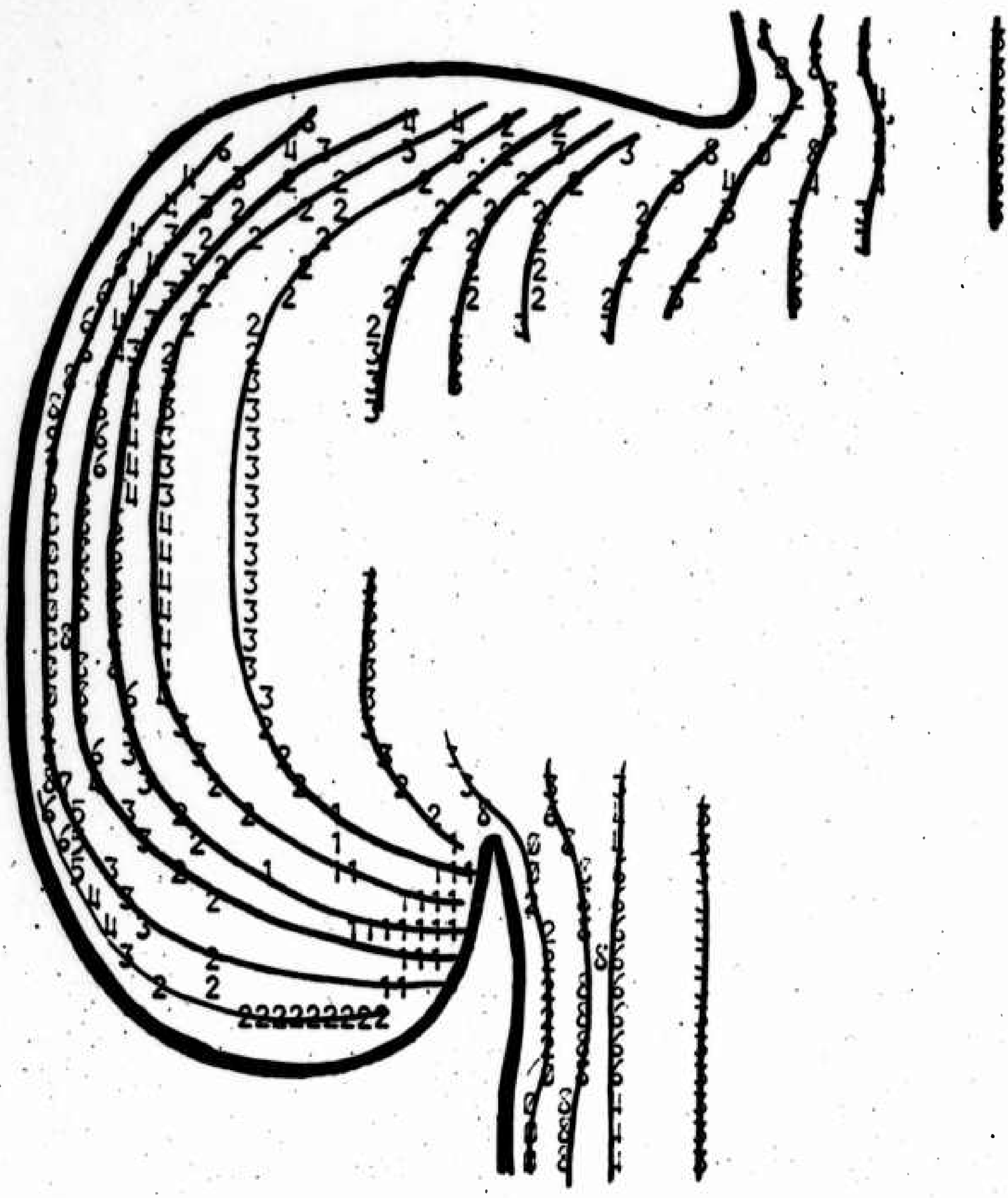


Figure A. 3. Analyzed Sea and Surf TELEPLOT of figure A. 2. Note that the tens digit is omitted for the height of the surf along the center of the beach and at each point of land.

sent in sections to be joined at the receiving facility, so the scale of the data is flexible, figure A. 4.

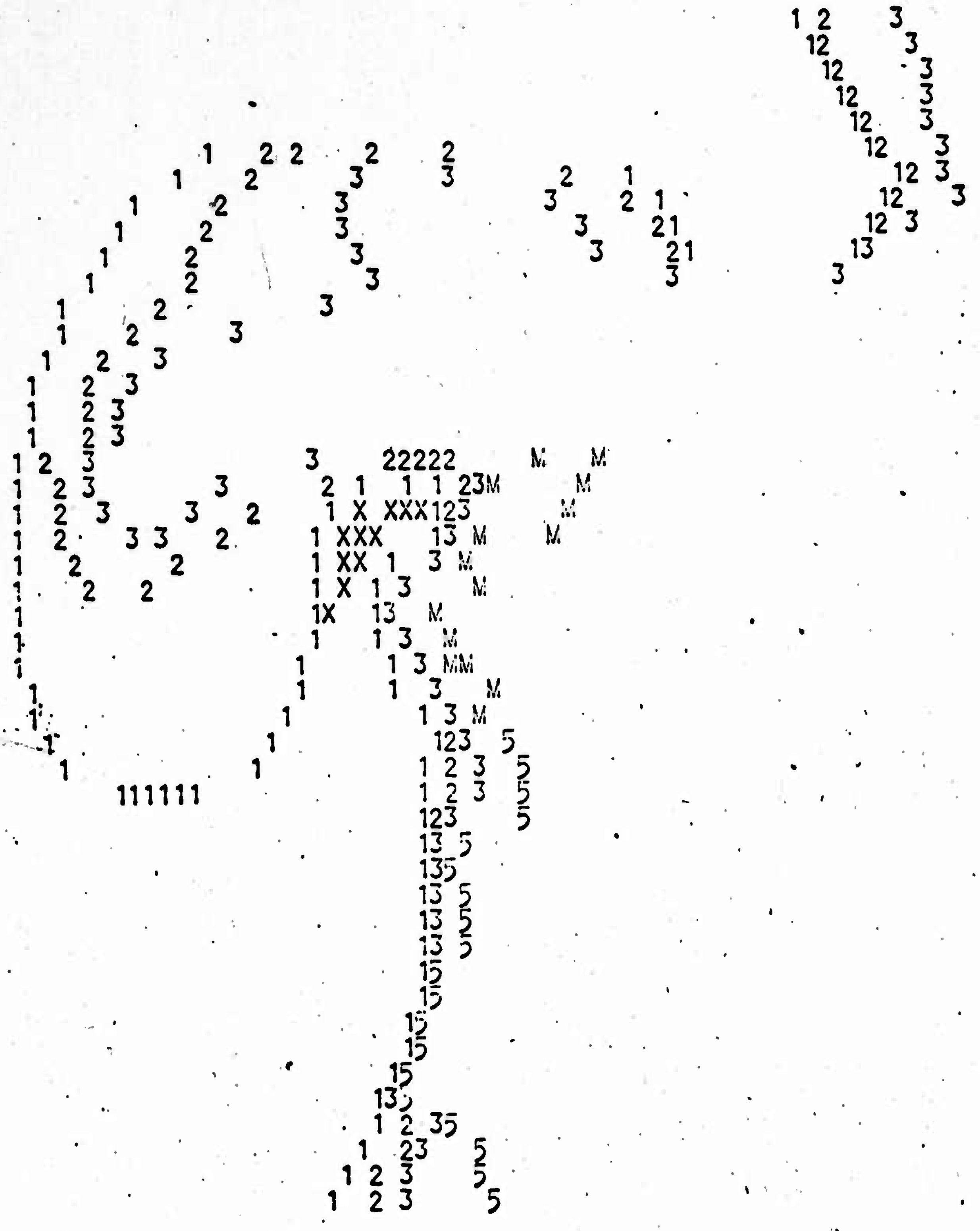
Figure A. 5 is the analysis of the UDT TELEPLOT report. The same method of chart alignment and orientation as the above would be used. The digits indicate the depth of the water at some convenient interval, e. g., fathoms. The "X" indicates rocks, and the "M" indicates the location of a mine. The UDT survey, in actuality, would have to be done before the sea and surf analysis could be completed.

6. Refractive Index

The Refractive Index TELEPLOT is designed to present refractive index data over a wide area. The grid in this particular TELEPLOT is approximately 120 nautical miles to a side (2 degrees latitude and longitude). The data block allows space for three layers, with the lowest layer at the bottom of the data block and proceeding upward for higher layers. For layer continuity, the whole picture should be considered. For instance, at one position there may be a single layer at 7,000 feet; at another position there may be additional layers at 4,000 and at 12,000 feet. If the layer at 7,000 feet were initially placed in the lower position, it would have to be stepped when the 4,000 foot layer was plotted. Therefore, the initial data entry may be in either the lower, middle, or upper position of the block depending upon the data in the surrounding data blocks.

The chosen format is $h_bh_bNh_th_t$, where h_bh_b is the bottom of the layer in thousands of feet, and h_th_t is the top of the layer. If the layer altitudes are less than 1,000 feet, 9 is used as a decimal point; i. e., 98 = .8 x 1000 = 800 feet. N

Figure A. 4. Underwater Demolition Team TELEPLOT Report for overlay onto a navigational chart. Latitude and Longitude benchmarks omitted.



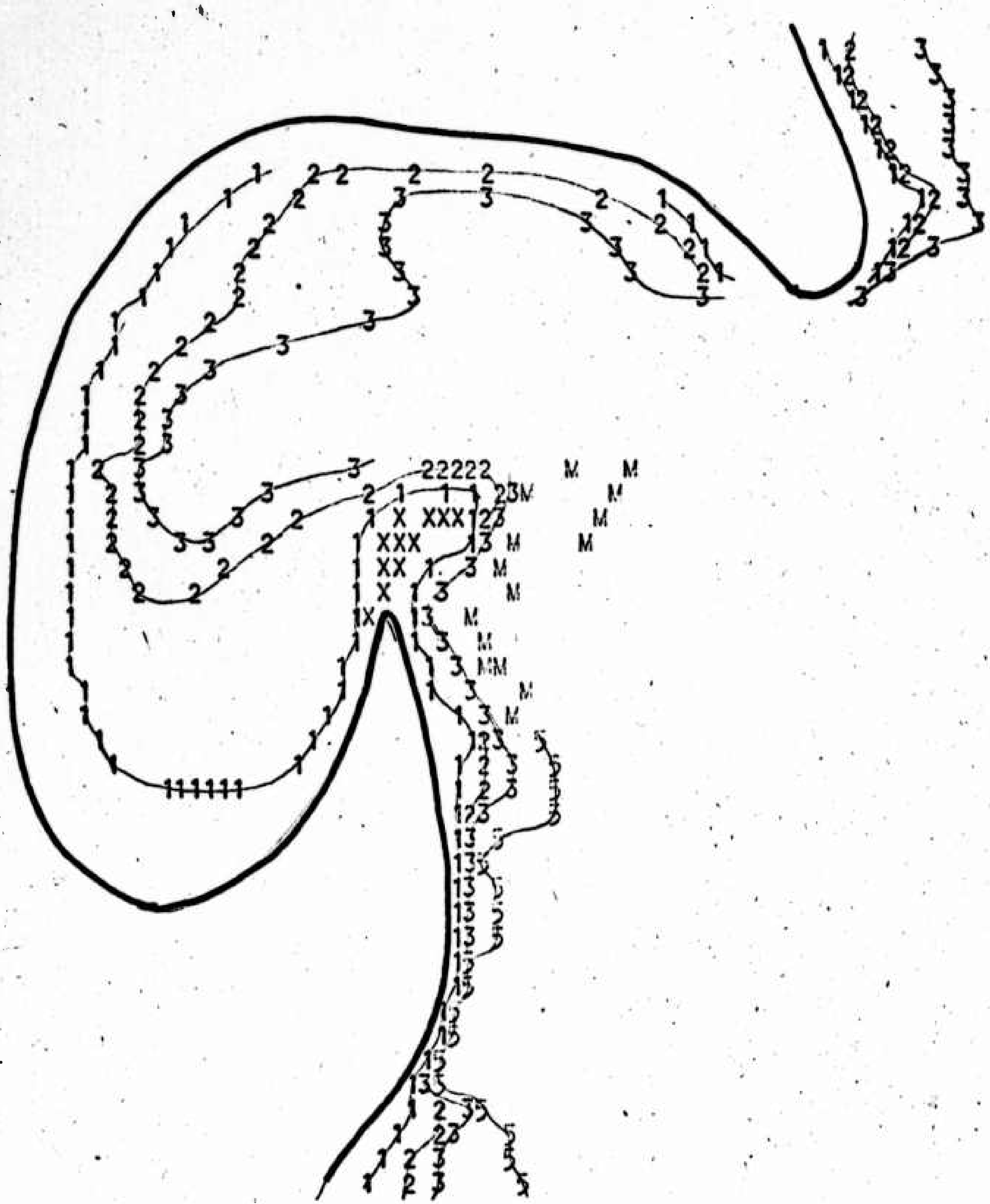


Figure A.6. Analyzed UDT TELEPLOT Report. Depth of water in fathoms, "X" stands for rocks (less than 1 fathom), and "M" indicates the location of a mine.

is the code figure for the N units per thousand feet.

N Gradient	Code
0 to (-24)	Blank
(-24) to (-30)	0
(-30) to (-36)	1
(-36) to (-42)	2
(-42) to (-48)	3
(-48) to (-54)	4
(-54) to (-60)	5
(-60) or greater	6
0 to (+6)	7
(+6) to (+12)	8
(+12) to (+18)	9
(+18) to (+24)	X
(+24) or greater	Y

The Refractive Index TELEPLOT (fig. A. 6) is designed to be usable by either surface or aviation commands. The analysis of the TELEPLOT is quite simple, knowing the characteristics of the radio or radar equipment, the user enters the table with the minimum N-gradient that will affect his equipment. For instance, the CIC officer on a ship with equipment with emissions which will be trapped under conditions with an N-gradient of greater than -48 N/1000 feet, or 4 in the code table should search the Refractive Index TELEPLOT for all values 4 or

REFRACTIVE INDEX TELEPLOT

	80	78	76	74	72	70	68	66	64	62	60
36	07208	07208	07208	08009 06307	08009	08109 98402	12014 98402	12014' 08110 98502	08210 98502	11013 08209 99402	11012 01302
34	07208	07208	06300	06307	08009 06307 98402	08009 98402	08109 98402	08209 98402	08510 98502	08510 98502	08509 99402
32	07208	06308	06308 98402	97501	97501	08009 97501	08209 97501	08209 97501	08209 97501	08310 98401	08509
30	97501	06308 97501	06308 97501	97501	97501	11012 97501	11012 08209 97501	11112 08209 97501	11012 08209 97501	11012 08209	08309

	80	78	76	74	72	70	68	66	64	62	60
36	07208	07208	07208	08009 06307	08009	08109 98402	12014 98402	12014 08110 98502	08210 98502	11013 08209 99402	11012 01302
34	07208	07208	06300	06307	08009 06307 98402	08009 98402	08109 98402	08209 98402	08510 98502	08510 98502	08509 99402
32	07208	06308	06308 98402	97501	97501	08009 97501	08209 97501	08209 97501	08209 97501	08310 98401	08509
30	97501	06308 97501	06308 97501	97501	97501	11012 97501	11012 08209 97501	11112 08209 97501	11012 08209 97501	11012 08209	08309

4 4 4 4 4 1 1

Figure A. [illegible] A [illegible] R[illegible] TELEPLOT. Re[illegible] [illegible] table of [illegible] index codes. The area [illegible] code 4 [illegible] ship's radar and the a[illegible] code 1 [illegible] the aircraft [illegible].

greater in the center spaces (solid line). He can then plot his ship's position directly on the TELEPLOT, determine the atmospheric effects upon his equipment, and see what position changes would improve his situation.

In another example, an aircraft is planning to fly through this same area at 8,000 feet. He has determined that his equipment will be affected by an N-gradient of -30 N/1000 feet, or 1 in the code table. He searches the TELEPLOT for all values 1 or greater in the vicinity of 8,000 feet (the dashed line). To receive optimum performance from his equipment, he can either avoid the affected area, change altitude, or at least take the effects in the account, figure A. 7.

7. The Ice TELEPLOT

```
ICE TELEPLOT

   766666666665555555555444444
   098765432109876543210987654

62 66//6666666666866666//////
61 6666666666666666866666/////
60 66666/666665686668666886688//
59 6656//6666556866668666886886
58 5566///665 568668866777
57 ////////665 578868877
56 ////////665 57788877
55 /////////665 57767
54 //////////655579  9
53 ///////////6 9  9
52 /////////////24
51 /////////////244 9
50 /////////////2444
49 //22222222244/144    9
48 1144444    1////214
47 //////44 2/////2444
46 //////214444 22449
45 ///////////44 444   9 9
```

Figure A. 8

The Ice TELEPLOT is so straightforward and obvious that no analysis is required. The slants represent land areas — Canada on the left, Greenland on the right. Using the WMC code 0663, we see that 1 is new ice, 2 is fast ice, 4 is packed (compact) slush or sludge, 5 is a shore lead, 6 is heavy fast ice, 7 is heavy pack ice/ drift ice, 8 is hummocked ice, and 9 is icebergs. The longitude is along the upper border, latitude is along the left border.

APPENDIX B

AVIATION TELEPLOTS

Aviation products are somewhat more complex than surface environmental products, since the data must be four dimensional (area (x and y), altitude (z), and time (t)). The straightforward product will present few problems to the knowledgeable aviator or operations officer; however, more involved interpretations require the services of meteorological personnel in order to derive the optimum benefits.

Again, the aviation TELEPLOT method is designed for all aviation and meteorological facilities but is primarily aimed at offering assistance to the smaller facilities and ships with their limited facilities and personnel allowances. In general, TELEPLOT offers products that are as preplotted and preanalyzed as possible to reduce the total time between the observation and the briefing.

1. Surface Weather TELEPLOT

The weather forecaster aboard ship or on an air station is responsible for environmental forecasts from which decisions are made or modified. Upon these decisions depend the safety of men, ships, and aircraft, mission accomplishment, and success in battle. To perform properly in this responsible position, the forecaster must have the proper tools. In recent years, this has meant the addition of ever increasing amount of raw data. This trend has continued until a single forecaster (as aboard an aircraft carrier) does not have time to scan and decode all the environmental data which is available, much less to analyze it. As a consequence, much of the data which is observed, coded, and transmitted at a consider-

able expenditure of time and money is not used by the ship forecaster or the air station with a small meteorological personnel compliment.

Radioteletype data is intended to include many compromises, giving as much information to as many users as possible. As a consequence, the Navy ship operating in the Atlantic or Pacific receives approximately the same data as the agricultural station in Iowa. This data can be divided into three general categories: Data that is analyzed in great detail because it is required for forecasting and briefing; data that is grossly analyzed because it may affect the operating area at a later time; and data that is of no value and is usually not plotted.

The Navy weather centrals and facilities could provide a filter for incoming data, eliminating data not pertinent to Navy problems and rearranging the remainder into its most usable form. The format should be designed for Navy operational requirements in the particular area of responsibility. For instance, Fleet Weather Facility Kodiak, Argentia, and Keflavik would be concerned with ice conditions, but this data would be wasted on Norfolk or Jacksonville. However, each central or facility would have responsibilities to provide general services to Navy ships or units within their areas of responsibility.

The TELEPLOT method is proposed to solve many of these problems. The weather chart is divided into regional grid squares with 540 mile sides, which is a slightly smaller scale than the 1:5,000,000 chart used on some of the current weather charts. The computer would be programmed to sort the data and then to arrange it into the proper grid and into the correct position within the grid. The teletype tape of rearranged data is then transmitted. It is received as a preplotted

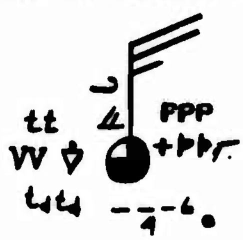
weather map, or TELEPLOT. A computer program for rearranging synoptic weather data from a standard incoming teletype tape to produce TELEPLOT weather charts was established experimentally at the U. S. Navy Weather Research Facility in May 1966.

The TELEPLOT is a handy clipboard size that is ideal for briefing in the restricted area of a bridge, particularly at night when the only prop is a red lensed flashlight. Each TELEPLOT matches the adjacent one so there is no problem in increasing the data coverage, should a ship be close to the edge of a TELEPLOT, or a larger coverage be desired. Longitude is printed vertically along the top of the TELEPLOT; latitude is printed horizontally along the left border.

The coding for the format has been restricted to data that is presently being used, FM 11 for shore stations, and FM 21 for ships. The present FM 11. C encodes surface synoptic weather data in the format:

iii Nddff VVwwW PPPtt $N_h C_L h C_M C_H$ $t_d t_d app$, etc.

The data is then decoded and plotted , partly in symbols and partly numerically, around the station symbol that is located on a large weather chart.



This symbolic plotting obviously cannot be done efficiently by the computer. However, the steps of decoding, of searching for the station location, and of

hand plotting of the data can be eliminated. By minor rearrangement of the code into a more usable form and positioning the TELEPLOT code format at the station position, analysis can be commenced immediately upon receipt of the data.

The shore station surface weather data TELEPLOT format is:

$i\ i\ i\ V\ V\ w\ w$		L C H 9 1 4 2
$N\ N_h\ h\ C_L C_M C_H W$		6 3 2 4 1 1 4
$t\ t\ P\ P\ P\ p\ p$	numerically:	7 5 1 3 0 1 6
$t_d\ t_d\ d\ d\ f\ f\ a$		7 4 2 3 1 0 2

The same format is used for ship data, with the exception that the time (GG) is used instead of the station call letters or numbers, and the sea water temperature ($t_s t_s$), wave group ($d_w d_w P_w H_w$), and the ship's course and speed ($D_s v_s$) are added at the end of the report.

$$\begin{array}{l}
G\ G\ \ V\ V\ w\ w \\
N\ N_h\ h\ C_L C_M C_H W \\
t\ t\ P\ P\ P\ p\ p \\
t_d\ t_d\ d\ d\ f\ f\ a \\
t_s\ t_s\ d_w\ d_w\ P_w\ H_w \\
D_s v_s
\end{array}$$

The data is arranged in a logical order to facilitate its use without transformation. Following the station identifier for shore stations, or time for ship observations, is what might be termed the visual observation grouping (visibility, weather, and clouds). In the first line are the visibility and weather (VVww), and in the second line is the cloud collective and the past weather ($NN_h h C_L C_M C_H W$), which are of priority importance. The temperatures (tt, $t_d t_d$, and $t_s t_s$) are arranged in vertical order for rapid comparison of air, dew point, and water temperature spread. The

pressure (PPP) is located at the center of the report so that the isobars in pressure analysis will be correctly located in relation to report position. The amount of pressure change (pp) is grouped with the pressure for easy reference. The pressure change characteristic is located below the pressure change group on the next line because of space limitations. The wind group (dd ff), which is an aid in drawing isobars, is located under the pressure (PPP). The wave group, which is part of the ship collective ($t_s t_s d_w d_w P_w H_w$) and an add-on to the basic shore station report, is located on the next line. The ship course and speed ($D_s v_s$), which are necessary in evaluating the accuracy of the reported wind and other parameters, are given at the end of the report.

A plastic overlay with topographical features and the exact geographical locations of the various stations would be required for land TELEPLOTs, or those that included a coastal section. The computer would be programmed to select, arrange, and position a preselected array of stations so that the data would have at least one blank space between it and the next report at the sides. Where possible, the data block would be positioned so that the second digit of the pressure (PPP) would be over the geographical location of the station. The station location should always fall somewhere within the data block if it cannot be located exactly under the second digit of the pressure group. A shadow line on the plastic overlay should be printed to connect the computer positioned data block center with the station position. Station reports which cannot be located on the TELEPLOT are to be typed under the TELEPLOT after being arranged by position, from left to right, starting at the top and using nearly the same code as the

TELEPLOT, e.g.:

$$iii \quad VVwwW \quad NN_h h C_L C_M C_H \quad ttPPPapp \quad t_d t_d ddff$$

Frequently, ship reports are received too late to be sent on regular teletype schedules. However, the reports are particularly valuable to ship meteorologists, if we consider the paucity of data under the best conditions. Ship data received after the TELEPLOT tape has been cut would be labelled by time (GG), arranged, and prepared for the next TELEPLOT. Data which would be 12 hours old at the observation time of the next TELEPLOT would be discarded. If two ship report data blocks overlap, the one with the later observation time would receive priority. If both reports were of the same observation time, the first one received would have priority for the space. Ship reports that do not have room on the TELEPLOT would be printed below it from left to right, top to bottom, e.g.:

$$L_a L_a L_a \quad L_o L_o L_o GG \quad VVwwW \quad NN_h h C_L C_M C_H \quad ttPPPapp$$
$$t_d t_d ddff \quad t_s t_s d_w d_w P_w H_w \quad D_s v_s$$

Weather charts, in general, are very conservative of space. By that we mean that a station or ship report is a grid point for 16 isopleths of weather information if it is a shore station or 20 isopleths, if it is a ship. If every value were isoplethed, the chart would become a hopeless jumble of lines. Even though lines are not drawn for all the data, during the process of the analysis, the analyst mentally integrates the various parameters into the overall picture. Little is accomplished by separating individual parameters to individual charts, because the

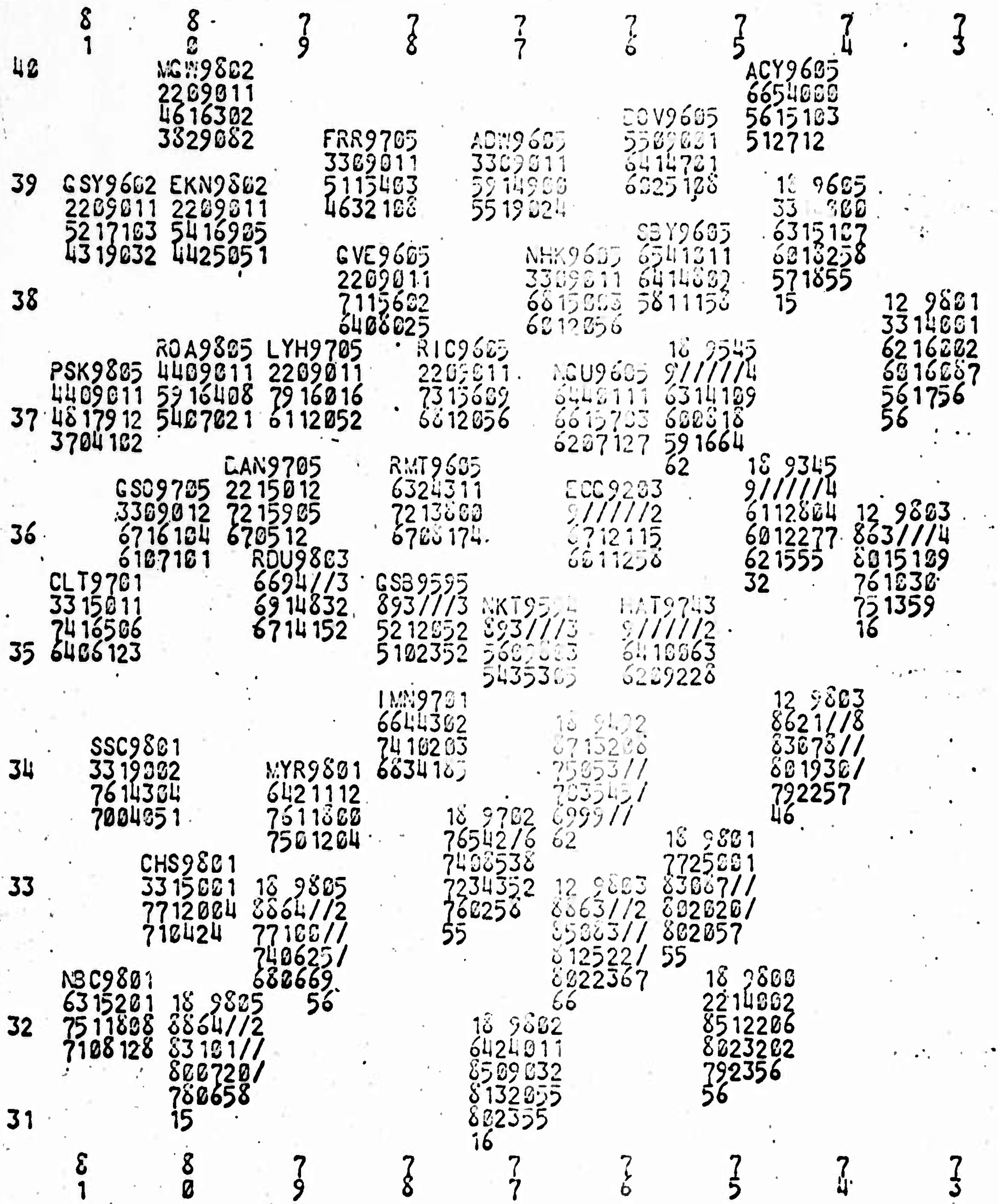
forecast is based upon the total picture, not just the temperature or some other single parameter. However, should there be a special requirement to consider only one parameter, it can be easily lifted from the data by isoplething it onto a separate plastic overlay.

Figure B.1 is a surface weather TELEPLOT as it would appear when removed from the teletypewriter, using the format as previously mentioned. Generally, a blank space separates individual stations. However, if stations are offset in the vertical axis they can abut the station above or below it without ambiguity; e.g., GVE, LYH and RIC, DAN and RDU, and GSO and CLT. If a ship observation could not be positioned correctly solely because of the ship course and speed group ($D_s v_s$), the course and speed group may be moved to the opposite side of the data block, as in the case of the ship at 32.6°N, 78.9°W.

Significant stations, particularly military airfields, that cannot be typed on the TELEPLOT would be typed below the TELEPLOT in the modified format. On this TELEPLOT the number would be about 3 to 6 additional lines to give a complete weather chart.

All available stations, whether programmed for the TELEPLOT or not, should be positioned on the overlay. The meteorologist must continually have the operational requirements in mind. To assist him in integrating these requirements, the station symbols should signify the facilities available at each station. On the operational overlay, military and civilian airfields with various runway lengths and facilities, should have some distinguishing symbol.

Figure B.1. Surface Weather TELEPLOT. [illegible] the synoptic data rearrangement computer program [illegible] at NWRF in 196[illegible].



1.1 Conventional Analysis

Figure B. 2 is a conventional pressure pattern and frontal analysis. The overlay should be placed initially under the TELEPLOT on a light table and the exact geographical position of each of the land stations transferred to the TELEPLOT with a dot. As the analyst becomes familiar with the format, this will normally be the extent of the plotting required. However, to provide a transition between the plotted chart and the TELEPLOT, the pressure (third line, center 3 digits) has been underlined, and the wind (fourth line, center 4 digits) has been plotted symbolically. The overlay is then put on top of the TELEPLOT and the analysis proceeds in a conventional manner. Note the "out of phase" wind on the ship at 31.3°N., 77.0°W. The wave group (fifth line, last 4 digits) indicates that the waves are coming from 230°, as are the waves at other ships in that area on that side of the front. A check of the ship's course and speed, line 6 (NE, 16-18 knots), indicates that the observer may have transmitted the relative wind instead of the computed true wind, an all too frequent occurrence.

1.2 Salient Weather Analysis

The pressure pattern analysis is one step in a series of steps that an analyst makes to determine the overall pattern of weather developments; this step, however, is not required to provide briefing data for existing conditions, as figure B. 3 demonstrates. The visibility code figure 96 (first line, fourth and fifth digits) is the equivalent of 4 kilometers, or 2.48 miles. Therefore all visibility codes 96 or less are areas of instrument conditions because of visibility. Proceeding to the sixth and seventh digits, also on the first line, we can read the

Figure B.2. Conventional Pressure Pa... Analysis of the Surface Weather TELEPLOT, ...

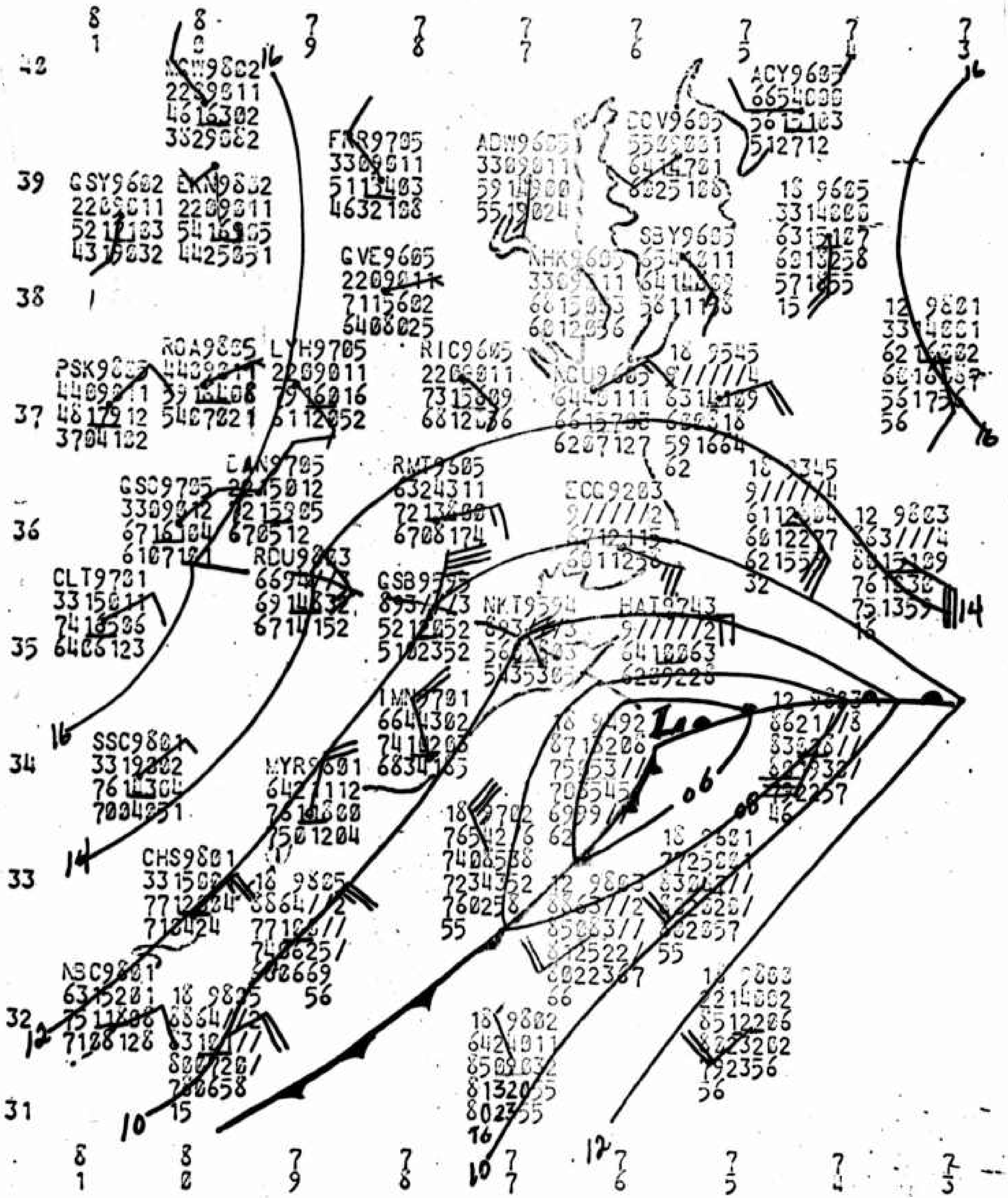
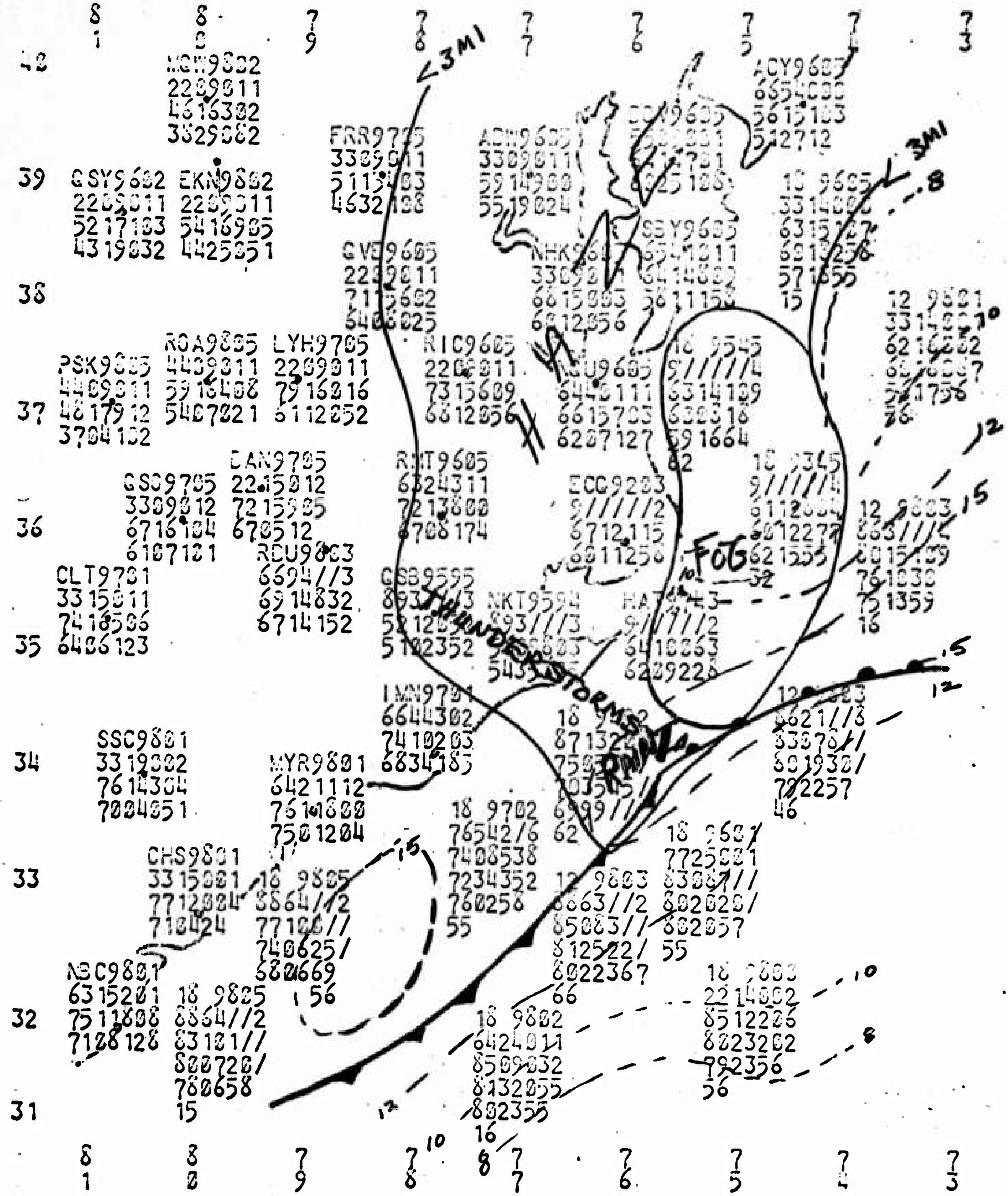


Figure B. 3. Salient Weather Analysis of the Surface Weather TELEPLOT, Figure B. 1.



present weather in code format. The forties indicate fog, and the nineties are showery type precipitation; thus, these areas can be quickly outlined. Of direct interest to the Navy are the sea conditions, the last 4 digits of the fifth line. The wave height isopleth, with the salient weather features as mentioned above, provides sufficient data for briefing in a matter of a few minutes.

2. Approach/Landing Conditions TELEPLOT

Aboard an aircraft carrier or ashore at a naval air station, most of the weather forecaster's problems deal with aircraft approach and landing conditions. The factors having the greatest effect on landing conditions are runway condition, visibility, clouds, weather, and wind; at sea, the height of the sea and swell is a significant factor. To describe these conditions on a TELEPLOT, the chosen format is:

$$\begin{array}{ccccc} V & N & h & W_1W_1 \\ d & d & f & f & E \end{array}$$

V - Surface visibility (WMO code 4300);

N - The fraction of the celestial dome covered by clouds (WMO code 2700);

h - The height of the base of the clouds above the ground (WMO code 1600);

W_1W_1 - Forecast surface weather (WMO code 4687);

dd - The true direction from which the wind is blowing in tens of degrees (WMO code 0877);

ff - Wind speed in knots;

E - At shore stations, state of the ground (runway condition, WMO code 0900). At sea, the combined sea and swell height. Multiply the code number by 3 for the significant wave height.

Figure B. 4 is the TELEPLOT as it would appear when it is removed from the teletypewriter. Longitude, in vertical orientation, is given along the top and latitude along the sides. The shore station data is labelled by the station call letters and computer positioned as close to the geographical position of the station as possible. Data over the ocean is in one-degree grid blocks, which distinctly outline the coastline without the use of a plastic overlay. However, an overlay to outline the coast and to locate exactly the stations presented would be of assistance in analysis. Figure B. 5 is one form of analysis that can be performed on this data.

From the weather pattern (the last two digits in the top line) and the wind pattern (the first four digits on the bottom line) there is an apparent frontal system with a low center between Cherry Point (NKT) and Elizabeth City (ECG). On the top line, the first digit represents the visiblity. Less than 6 (4 to 10 kilometers = 2.5 to 6.2 miles) would be instrument conditions (IFR because of visibility). The second digit symbolizes the eights (oktas) of cloud cover. The third number is the height of the base of the clouds (4 = 300 to 600 meters = 984 to 1968 feet). Therefore, less than the code digit 4 is instrument conditions (IFR) because of ceiling height. The IFR area has been enclosed with a short dashed line. From the last two digits on the top line, a rain area has been defined with a long dashed line.

The last digit in the bottom line represents the runway or ground conditions at air stations. This information is essential during the summer, when braking distance is increased by wet runways, but vital during the winter with ice or snow covered runways, which in essence closes many fields to aircraft without reverse thrust or drogue chutes. At sea, the height of the waves is a major

Figure B.4. Approach/Landing Conditions TELEPLOT.

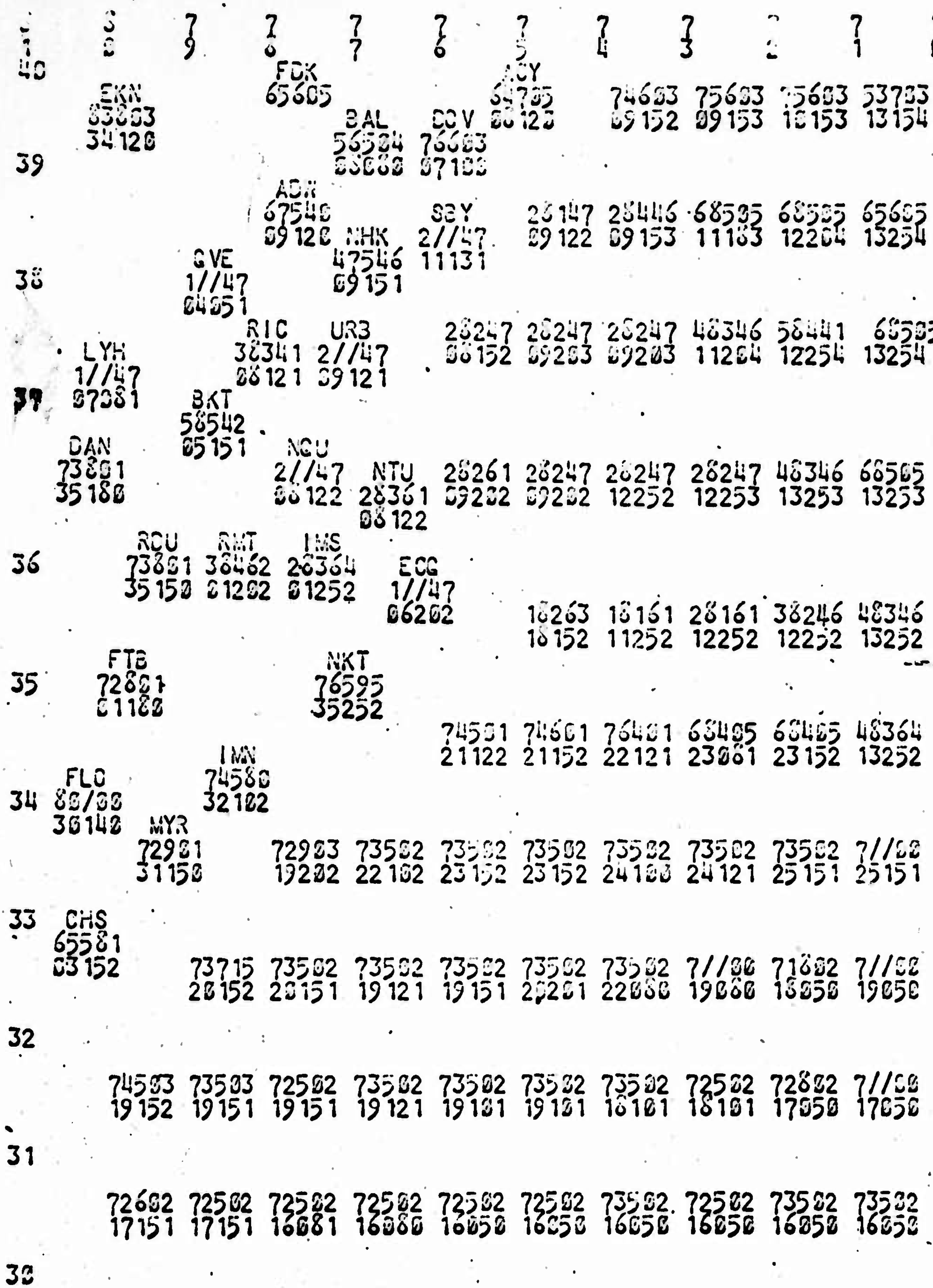
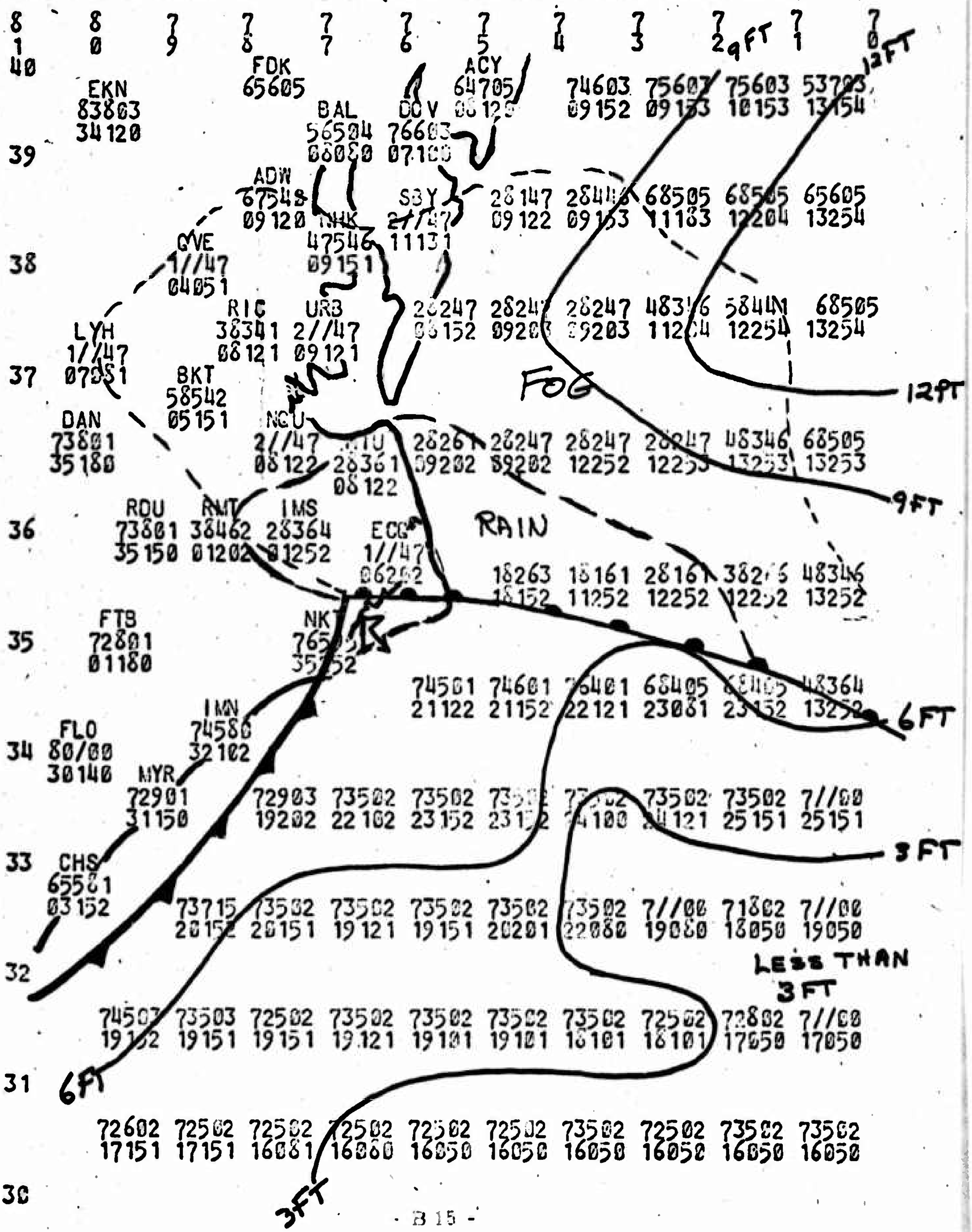


Figure B.5. Analysis of the Approach/Landing Conditions TELEPLOT.



factor in the safety of aircraft carriers and ship operations. The sea heights are analyzed in 3-foot units and isoplethed with a solid line. Other analyses that could be as easily performed include isogon-isotach, cloud height, and visibility.

3. Horizontal Weather Depiction TELEPLOT (HWDT)

Horizontal Weather Depiction Charts and/or Vertical Weather Cross Sections are required for extended flights over water and are encouraged for all long flights. Unfortunately, there is a wide variation in the quality among locally produced products, which depend upon the amount of time and data available and upon the artistic ability of the analyst-forecaster.

The raw data requirements for even the most rudimentary horizontal weather depiction chart include several pibals, rawinsondes, terminal forecasts, and yards of surface observation teletype data. Just the search for the data and its proper assembly are projects in themselves. These data must then be analyzed individually before they can be collectively analyzed in order to produce a usable horizontal weather depiction chart. However, even the best field work cannot match the derivations, extrapolations, and speed of a central or facility computer.

In this example, HWDT, a one-degree latitude and longitude grid space has been accepted to be about the largest scale that could be used and still position weather phenomena with any degree of accuracy. Five spaces horizontally to 3 spaces vertically produces a square on the TELEPLOT, but in this case the chosen coding of environmental data requires 6 spaces (5 spaces of data and 1 blank space for data separation) horizontally to 3 spaces vertically. Minor variations of one space, either vertically or horizontally, do not cause serious dis-

proportionality to the product, but more than one space would distort the map quality of a TELEPLOT.

The most important data is positioned at the beginning and end of each group if possible. This is because the eye is more sensitive to variations of data in these positions, and this allows the analyst/forecaster to scan the page for significant features before analyzing the product.

The HWDT code gives the amount of clouds N(WMO code 2700), the type of clouds C (WMO code 0500), the weather W_1W_1 (WMO code 4687), and icing and/or turbulence J (WMO code 1900) in the following format.

$$\begin{array}{c} N\ C\ W_1W_1\ J \\ h_b h_b / h_t h_t \end{array}$$

The second line of the model format is the altitude (in thousands of feet) of the base h_bh_b and of the top h_th_t of the phenomenon described. If turbulence and/or icing (J) were forecast this would be the phenomena described. If no icing or turbulence was forecast, it would describe the significant cloud C. The number 9 would take the place of a decimal point for low stratus or fog with bases below 1000 feet, e.g.,

00 = surface

92 = .2 x 1000 = 200 feet

02 = 2000 feet

20 = 20,000 feet

By using adjacent data blocks to describe other significant data, we can produce a fairly complete description of sky conditions. The format can be improved

by using a letter and four digit number ($h_b h_b h_t h_t$) to designate some special phenomenon and to locate it by the altitude of its base and top. Some of these phenomena might be the jet stream J, contrails C, or a chaotic sky condition K, etc. The TELEPLOT group would then appear as:

7 8 1 8 3
K 0 1 2 5

Decoded, this group indicates that clouds cover 7 oktas, (9/10 or more of the sky, but not 10/10ths). Cumulus is the significant cloud type; squalls are the significant weather in this grid; and the last digit, 3, indicates moderate turbulence, but no icing. The letter K in the second line indicates a chaotic sky with cloud bases at 1000 feet and forecast to reach 25,000 feet. Without the letter K, the altitude data would refer to the turbulence.

The envisioned TELEPLOT would appear as blocks of data without land masses or individual station forecasts designated. If the receiving station desired, plastic overlays of land masses, topography, airway routes, and individual stations could easily be prepared. As the example TELEPLOT (figure B.6) is a forecast for the area from 73°W. to 84°W. and 26°N. to 38°N., it supplies forecast data for air routes in the southeastern U. S., oceanic routes between NAS Norfolk and NAS Guantanamo, and data for the aircraft carriers in the Virginia Capes and in the Jacksonville, Florida Fleet Operating areas.

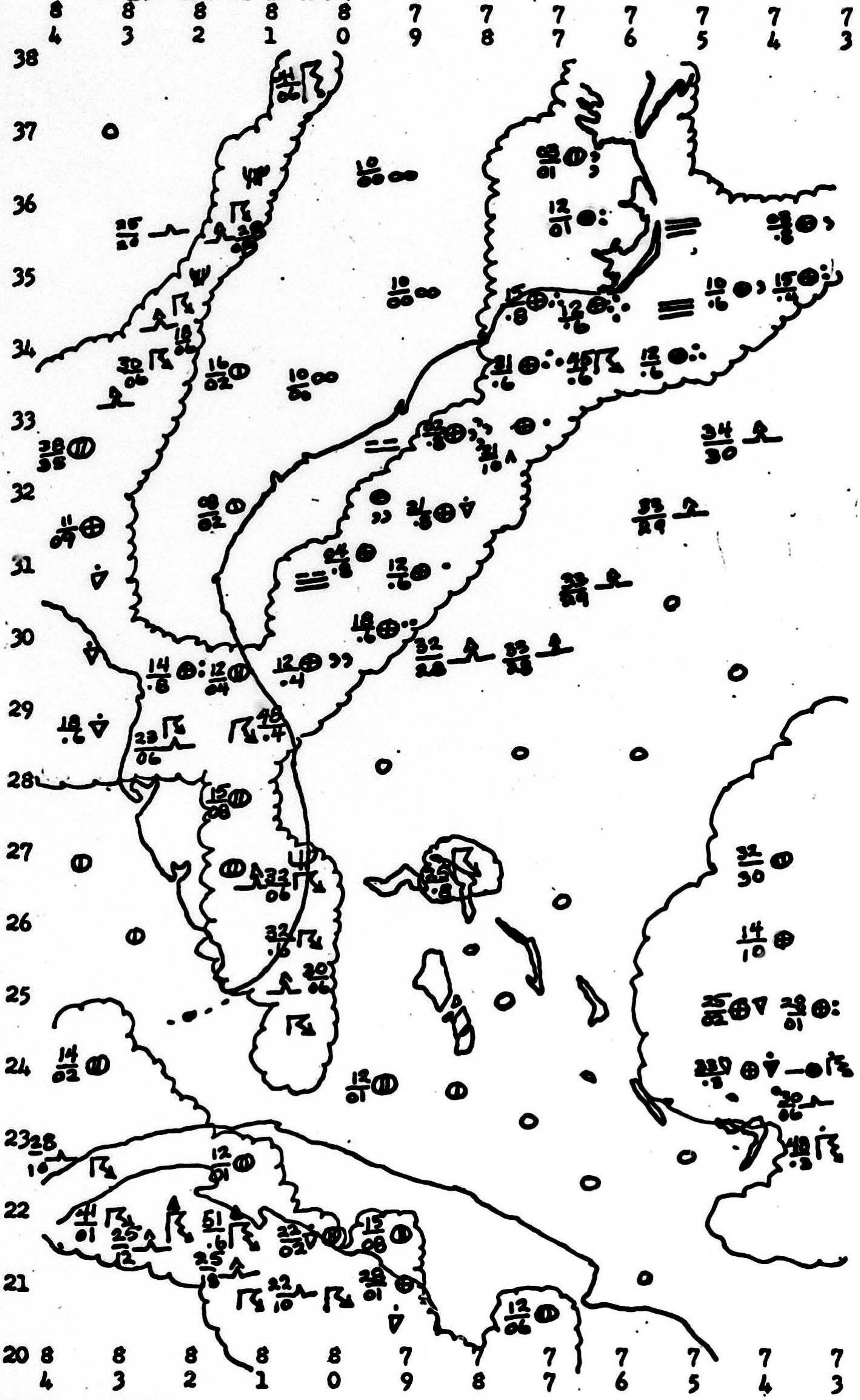
Figure B. 7 is the analyzed Horizontal Weather Depiction TELEPLOT as it would be presented to the aircraft commander with other weather documents. All that remains to be done is to plot the intended flight track.

HORIZONTAL WEATHER DEPICTION TELEPLOT

	84	83	82	81	80	79	78	77	76	75	74	73
38			30011 35136	89990 96141	051 00/10	051 00/10	051 00/10	63051 10/12	87461 01/02	051 00/07	051 00/07	
37			56011 02/05	28031 02/12	051 00/10	051 00/10	53051 12/15	57521 01/03	87461 98/03	27051 00/07	051 00/07	
36		003 20/25	89959 08/28	051 00/10	051 00/10	051 00/10	85511 00/00	85621 01/12	471 00///	87161 98/03	57501 98/03	
35	38021 38/39	59163 06/18	28031 02/12	051 00/10	051 00/10	43051 08/10	85631 98/15	85651 96/12	471 00///	85511 96/10	85621 94/15	
34	52021 35/38	89958 06/30	38031 02/16	051 00/09	051 00/08	23401 08/10	85630 96/31	89970 96/45	85631 96/12	85621 96/12	32021 28/29	
33	51021 35/38	51031 35/38	38021 02/10	28021 01/06	28411 01/06	87551 98/02	85623 10/21	38031 01/08	28011 01/08	31033 30/34	41021 28/29	
32	83031 09/11	33031 10/11	28021 02/08	46021 02/03	87501 98/04	85803 08/21	68800 01/10	28031 02/06	31034 29/33	28021 02/12	28021 02/06	
31	85601 99/08	43031 09/12	33031 09/11	87461 98/04	85601 96/12	85610 96/10	28031 01/06	31034 29/33		28021 02/06	28021 02/06	
30	85621 96/12	85621 98/14	58163 04/12	85511 94/12	85631 96/18	31034 28/32	31034 28/33	21021 27/28			31011 29/31	
29	85621 96/18	89953 06/23	89950 94/48	85801 94/25							62011 29/32	
28	28021 02/06	28031 02/15	68033 08/15	28030 02/08						62031 30/32	62021 30/32	
27	28021 02/12	28021 02/06	68030 01/14	89968 06/32	28021 02/12	89970 98/25				62031 30/32	72031 29/33	
26	28021 02/06	38021 02/12	89964 06/20	89960 96/32	28021 02/14				61031 31/32	84151 10/12	83031 10/14	
25	48021 02/12	38021 02/06	28030 02/12	89978 06/30	28021 01/10				61031 32/33	85801 02/25	85621 01/28	
24	58021 02/14	48021 02/10	28021 02/06	68030 01/18	48031 01/12	28021 02/06			61031 32/33	85821 93/33	89973 06/30	
23	89963 10/28	68032 01/15	68033 01/12	38033 01/06	28031 01/12					33031 10/12	89970 93/48	
22	89960 01/41	89998 12/25	89990 96/51	68030 02/22	68032 08/15					58031 38/40	88031 38/45	
21	32021 38/40	38031 01/12	89958 18/25	89953 10/22	88030 01/28	38031 01/20	48033 06/12				28031 38/40	
	84	83	82	81	80	79	78	77	76	75	74	73

Figure B.6. Horizontal Weather Depiction TELEPLOT (HWDT).

Figure B.7. Analyzed Horizontal Weather Depiction TELEPLOT (HWDT) for Weather Documents Packet.



4. Vertical Weather Cross Section TELEPLOT (VWCST)

There is enough data available in raw form to prepare a usable cross section for almost any air route in the United States on a 12, and possibly a 6, hour basis. Unfortunately, lack of time and a sufficient number of analysts and forecasters prevent such an attack on this tremendous quantity of data. Computers could reduce the derivations and extrapolations over fixed routes or a fixed grid of cross sections, so that forecasters on the ships or smaller facilities would have only minor finishing touches to add in order to complete a VWCST for a pilot's weather document packet or for use in operational thermodynamic or isentropic analyses.

The selected code format is:

$$N_S C \; t_c t_c J \;\; W_P$$
$$d_h d_h f_h f_h R \;\; R$$

N_s - The amount of individual cloud layer or mass (WMO code 2700) of genus C clouds at the designated altitude and position (grid block); for example, at 6,000 feet, the code could be 0, indicating no clouds at that position and altitude, while at 5,000 feet, it could be 8 (8 oktas). This would indicate that, at that particular position, the clouds completely cover the the 5,000 foot level, but the tops of the clouds do not extend to 6,000 feet.

C - Genus of clouds (WMO code 0500); this is the significant cloud type in this particular data grid block. If there are cumulonimbus from 1,000 to 35,000 feet, from an areal point of view, this is the most significant cloud type. However, since there are many levels to identify this massive cloud structure, if one level had a stratus deck of clouds, the stratus

clouds should be identified. Slants are used for N_s and C to indicate the absence of clouds in the particular data block.

$t_f t_f$ - Air temperature in the grid block in whole degrees celsius;

J - Aircraft icing and turbulence (WMO code 1900);

W_p - Type of precipitation falling in the grid block (WMO code 4647);

$d_h d_h$ - True direction from which the wind is blowing in tens of degrees (WMO code 0877);

$f_h f_h$ - Wind speed (knots); WMO conventions for wind speeds over 99 knots apply.

RR - Refractive index in N units; the hundreds digit is dropped, e.g., N = 343, RR = 43.

Where specific air routes are services routinely by the Navy Weather Service Environmental Detachments, data from a facility with computer capabilities could save hours of laborious sorting and plotting. Figure B.8 is an example of a Vertical Weather Cross Section TELEPLOT between NAS Norfolk and NAS Guantanamo Bay, Cuba. The geographic location of the data columns would be predesignated (Norfolk, Wilmington, CARP [30°-25'N, 77°-47'W], ABACO [27°-00'N, 77°-34'W], Nassau, Y-2 intersection [23°-00'N, 74°-16'W], Great Inagua Island, and NAS Guantanamo). The teletypewriter paper is 69 spaces wide. In the VWCST it is used thus: 2 spaces for altitude, 1 space separation. Data blocks use 6 plus a space separation, or a total of 7. On this VWCST, 8 blocks are pre-designated, leaving space for an extra column of data. This is intended for use in defining phenomena which do not fall close enough to the other data and columns. In this

Figure B.3. Vertical Weather Cross-Section TELEPLOT (VWCST).

VERTICAL WEATHER CROSS SECTION

	ORF	ILM	CARP	29N	ABACO	ZQA	Y 2	ZIN	NBW
50	0/941/ 302571	0/931/ 312572	0/041/ 312576	0/051/ 282521	0/051/ 051082	0/061/ 040582	0/081/ 052088	0/111/ 061590	0/121/ 072095
45	0/961/ 333080	0/961/ 334081	41003/ 324592	800036 241550	42062/ 351090	0/063/ 351092	0/083/ 284094	0/103/ 284098	0/111/ 273004
40	0/971/ 334584	0/971/ 335086	0/983/ 326090	809636 335051	0/051/ 334093	0/061/ 343008	0/063/ 302010	0/081/ 292012	0/081/ 292018
35	0/971/ 324090	0/961/ 327092	0/942/ 297099	299036 286059	0/041/ 284001	0/041/ 292011	0/051/ 292014	0/061/ 281518	0/061/ 271021
30	0/901/ 304098	0/881/ 316000	0/864/ 784008	287837 288070	0/941/ 286513	0/941/ 285024	0/961/ 272028	0/031/ 272533	0/041/ 272038
25	0/831/ 325009	0/851/ 328011	0/824/ 788018	296927 278078	0/851/ 276026	0/851/ 276036	0/861/ 274040	0/871/ 282043	0/881/ 272048
20	0/731/ 325018	0/731/ 328021	0/724/ 788028	435858 278091	0/761/ 276038	0/761/ 274550	0/771/ 303051	0/781/ 311553	0/791/ 313560
18	0/701/ 303028	0/701/ 314030	0/691/ 306036	295657 284000	0/721/ 273543	0/721/ 303063	0/731/ 312035	0/731/ 320568	0/731/ 342075
16	0/671/ 292541	0/661/ 303543	13602/ 295058	485288 295020	86622/ 262551	36641/ 273076	0/641/ 293078	0/631/ 331080	14632/ 351596
14	0/641/ 292554	0/631/ 303555	0/561/ 294565	390398 284526	36551/ 292500	0/561/ 292090	0/571/ 322586	0/571/ 331592	18582/ 351536
12	0/621/ 282068	0/611/ 293070	0/011/ 294084	620098 284046	0/011/ 292020	13021/ 291531	13021/ 331533	0/031/ 341538	180125 352050
10	0/581/ 292080	0/581/ 271582	130720 273548	890988 284094	0/061/ 273036	0/071/ 261539	0/071/ 291040	0/081/ 292044	190925 302557
08	0/041/ 291003	0/041/ 281505	381030 272575	891248 264016	0/111/ 292060	0/121/ 301051	0/131/ 291056	0/131/ 281060	191035 271003
06	0/081/ 300526	0/091/ 290528	861331 272019	891348 293030	26122/ 263021	26162/ 312011	26162/ 052092	16161/ 021594	191635 272021
04	0/141/ 281550	0/141/ 291551	251425 292038	891538 303540	28163/ 282541	0/181/ 301035	0/192/ 031013	0/212/ 011016	162235 291052
02	87141/ 291036	56142/ 292038	482025 021047	891838 013550	88203/ 041056	0/212/ 031058	48212/ 053059	68212/ 073068	292235 073070
00	0/201/ 081554	0/221/ 072058	0/2425 092560	0/2238 154560	0/261/ 181566	0/271/ 111070	0/281/ 082076	0/271/ 082080	0/2715 113082

example, a thunderstorm along the cold front at 29°N. (on control airway 1151) has been described.

Figure B. 9 is a suggested preliminary blocking-in of cloud precipitation, and icing and/or turbulence data. Sky conditions (clear, scattered, broken, or overcast) are boxed in. Precipitation is denoted by a double vertical line along the cloud box. Turbulence is underlined, and icing areas are enclosed in slants.

From this crude block diagram, it is a simple transformation to make a master pictorial representation of the data on tracing paper; from this master tracing, Xerox or Ozalid copies can be reproduced as required for pilots' weather document packets, figure B. 10. Wind, refractive index, or other operational parameters could be listed in a table under the VWCST or along the flight route. In some operational situations, it might be preferable to Xerox the entire blocked-in TELEPLOT.

To avoid a fold-over page, only even levels from the surface to 20,000 feet, and levels at 5,000 foot intervals from 20,000 to 50,000 feet are shown. For operational applications, levels at every 1,000 feet are recommended below 10,000 feet.

5. Coastal Vertical Weather Cross-Section TELEPLOT

Upper level pressure surface charts over the oceans are largely extrapolation products because the observational data is so sparse. Operationally, their value is limited because of the difficulty of correlating the data vertically between the various charts. Therefore, extrapolated vertical weather cross-sections in the fleet operating areas along the coasts of the United States or in operational

Figure B.9. Pr[illegible] Block Diagram of the Vertical Weather Cross-Section [illegible]

VERTICAL WEATHER CROSS SECTION

	ORF	ILM	CARP	29N	ABACO	ZQA	Y 2	ZIN	NBW
50	0/941/ 302571	0/931/ 312572	0/041/ 312576	0/051/ 262521	0/051/ 051002	0/061/ 040582	0/081/ 052086	0/111/ 061598	0/121/ 072095
45	0/961/ 333080	0/961/ 334081	41003/ 324592	800036 241550	42062/ 351090	0/063/ 351092	0/083/ 284094	0/103/ 284098	0/111/ 273004
40	0/971/ 334584	0/971/ 335086	0/983/ 326090	809636 335051	0/051/ 334093	0/061/ 343008	0/063/ 302010	0/081/ 292012	0/081/ 292018
35	0/971/ 324098	0/961/ 327092	0/942/ 297099	299036 286059	0/041/ 284001	0/041/ 292011	0/051/ 292014	0/061/ 281518	0/061/ 271021
30	0/901/ 304098	0/881/ 316000	0/864/ 784008	287837 288070	0/941/ 286513	0/941/ 285024	0/961/ 272028	0/031/ 272533	0/041/ 272038
25	0/831/ 325009	0/851/ 328011	0/824/ 788018	296927 278078	0/851/ 276026	0/851/ 276036	0/861/ 274040	0/871/ 282043	0/881/ 272048
20	0/731/ 325018	0/731/ 328021	0/724/ 788028	435858 278091	0/761/ 276038	0/761/ 274550	0/771/ 303051	0/781/ 311553	0/791/ 313560
18	0/701/ 303028	0/701/ 314030	0/691/ 306036	295657 284000	0/721/ 273543	0/721/ 303063	0/731/ 312035	0/731/ 320568	0/731/ 342075
16	0/671/ 292541	0/661/ 303543	13602/ 295058	485288 295020	86622/ 262551	36641/ 273076	0/641/ 293078	0/631/ 331080	14632/ 351596
14	0/641/ 292554	0/631/ 303555	0/561/ 294565	390398 284526	36551/ 292500	0/561/ 292090	0/571/ 322586	0/571/ 331592	18582/ 351536
12	0/621/ 282068	0/611/ 293070	0/011/ 294084	620098 284046	0/011/ 292020	13021/ 291531	13021/ 331533	0/031/ 341538	180125 352050
10	0/581/ 292080	0/581/ 271582	130720 273548	820988 284094	0/061/ 273036	0/071/ 281539	0/071/ 291040	0/081/ 292044	190925 302557
08	0/041/ 291003	0/041/ 281505	381030 272575	891248 264016	0/111/ 292060	0/121/ 301051	0/131/ 291056	0/131/ 281060	191035 271003
06	0/081/ 300526	0/091/ 290528	861331 272019	891348 293030	26122/ 263021	26162/ 312011	26162/ 052092	16161/ 021594	191635 272021
04	0/141/ 281550	0/141/ 291551	251425 292038	891538 303540	28163/ 282541	0/181/ 301035	0/192/ 031013	0/212/ 011016	162235 291052
02	87141/ 291036	56142/ 292038	482025 021047	891838 013550	68203/ 041056	0/212/ 031058	48212/ 053059	68212/ 073068	292235 073070
00	0/201/ 081554	0/221/ 072058	0/2425 092560	0/2238 154560	0/261/ 181566	0/271/ 111070	0/281/ 082076	0/271/ 082080	0/2715 113082

VERTICAL WEATHER CROSS SECTION

ORF- V1, CONTROL 1151, YANKEE RTE, 3R 2L - ZIN - DIR - NBW

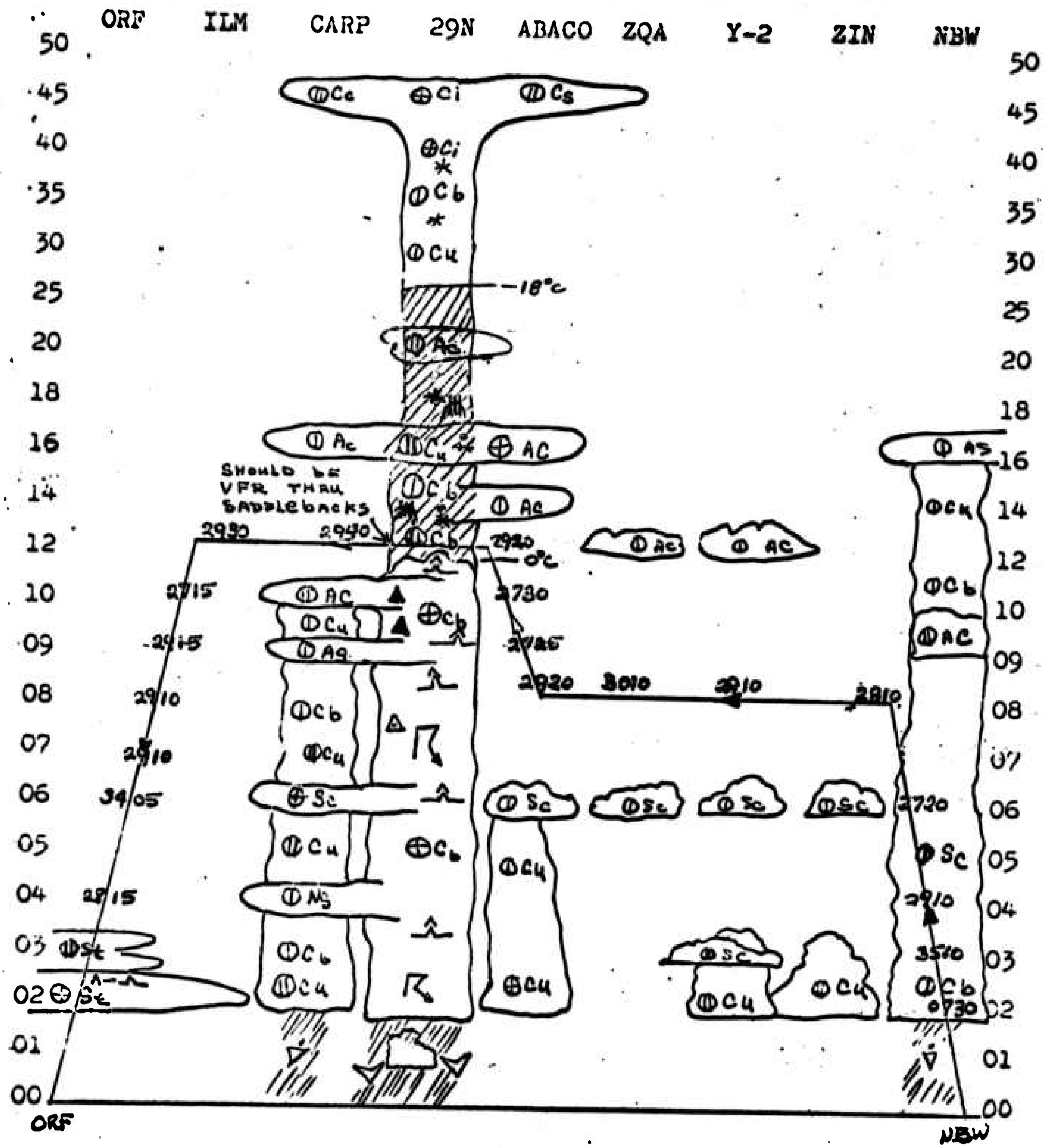


Figure B.16. A [illegible] Weather Documents Packet.

areas around the world could be of considerable value to aircraft carrier and missile ship meteorologists.

In this proposed method, the data is based upon a 2-degree grid extending seaward from the coastline east, south, or west, depending upon which coast is being considered at 2 degree intervals. Using the same format as proposed in section B 4, 9 data columns could be used in these cross sections, which would cover a distance of 1080 miles. If the data were extended 1 grid space inland, to cover bingo (emergency) field requirements, the cross section would extend to seaward 960 miles.

Since the VWCST grid is square, there should be little difficulty in working cross sections in a north-south direction from east-west oriented TELEPLOTs by matching the latitudes on two adjacent cross sections. This same VWCST grid could be extended over the U. S. or any operational area to provide a three-dimensional set of parameters for operational or scientific purposes.

6. Upper Air TELEPLOT

There are many systems of forecasting which require inputs of upper air data. Some of these data are sent over the teletype as raw data; much is transmitted by the facsimile system. The raw data, or data in the coded format, requires so much communications time that usually only representative stations are transmitted. If there were time to decode and plot these data, which there rarely is, the resulting upper air chart would have only enough data for the most rudimentary analysis.

Because of the communications problems created by these long teletype mes-

sages, the emphasis has shifted to completed upper air analyses sent by facsimile. There has also been a shift toward semi-hemispherical area coverage to include over-the-pole air routes. To transmit this increased area, the size of the map scale has also had to be increased, thereby decreasing the space per data bit. As the amount of data has not been significantly changed, unless it has been increased slightly, the analysis sometimes has areas of "data blot-out." In the "blot-out" area the station data is packed so closely that the chart is a mass of incomprehensible unseparated digits. When the isoheights are drawn through this area, any possibility of using the data disappears. These problems exist with land line facsimile. Aboard a moving ship, with its myriad electrical and electronic equipment creating electronic noise and garbling, the probability of receiving a chart legible enough for forecasting use approaches the vanishing point.

A TELEPLOT of the data would be somewhat more gross than the attempted data concentration on the facsimile, but it would be legible and usable. The chosen format is:

$$\begin{array}{l} t\ t\ d\ d\ f\ f \\ t_d t_d\ H\ H\ H \end{array}$$

Where t t is the temperature in degrees celsius, $t_d t_d$ is the dewpoint, d d is the wind direction in tens of degrees, f f is the wind speed, and H H H is the height of the surface in geopotential meters. The TELEPLOT figure B. 11 is based upon a grid of 3 degrees (180 nautical miles) to a side. The data is a computer integration, so stations as such do not appear. The geographical location of any particular station can easily be determined from its latitude (left border) and longitude (top and bottom border), or by the use of a geographic plastic overlay.

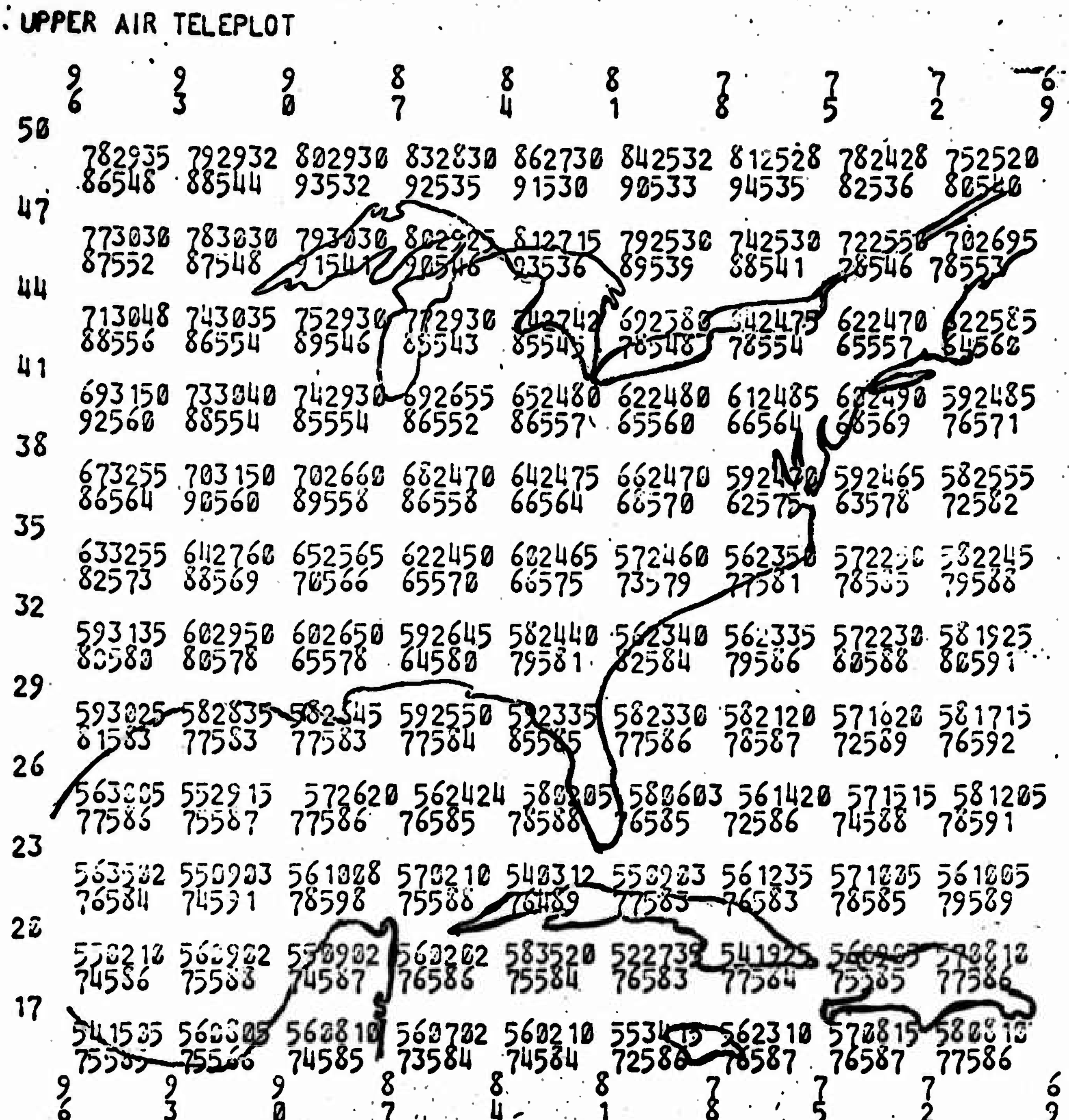


Figure B.11. Upper Air TELEPLOT, 500 millibar chart with geographic overlay superimposed.

Figure B. 12 is a standard analysis of the data. Solid lines are isoheights at a 6 geopotential meter separation. The short dash lines are isotherms at 5°C separation. The recommended procedure is to use a plastic overlay with geographical features and to perform the analysis on the overlay as was done in this figure.

Wind direction can easily be scanned from the TELEPLOT (the last four digits on the top line) for standard mid-latitude forecasting. By using several overlays, quite complex analyses can be performed, each on a separate overlay. An isogon-isotach (20 knot isotach separation) analysis is shown in figure B. 13. These analyses can be integrated by simply aligning the various overlays over the TELEPLOT.

7. The Hurricane TELEPLOT

This particular illustration is not a TELEPLOT in the strictest definition, because a teletypewriter is not involved in the initial steps, but the method is related and teletypewriters are used in the later phases. This problem is getting a reproduction of a radar scope picture from a hurricane hunter aircraft to the hurricane analysts and forecasters in real-time. It is a situation different from those previously mentioned in that the data is sent initially by CW key. This method could be applied to other operational situations where data can best be sent by teleplot, but only CW methods of transmission are available.

By pre-arrangement, or from the TELEPLOT Code and Format Manual, the sender and receiver use the same grid size and number designation. A Polaroid photograph of the radar scope is made and the plastic teletype grid placed over the photograph. Using a pre-arranged brightness scale, a brightness value is

UPPER AIR TELEPLOT

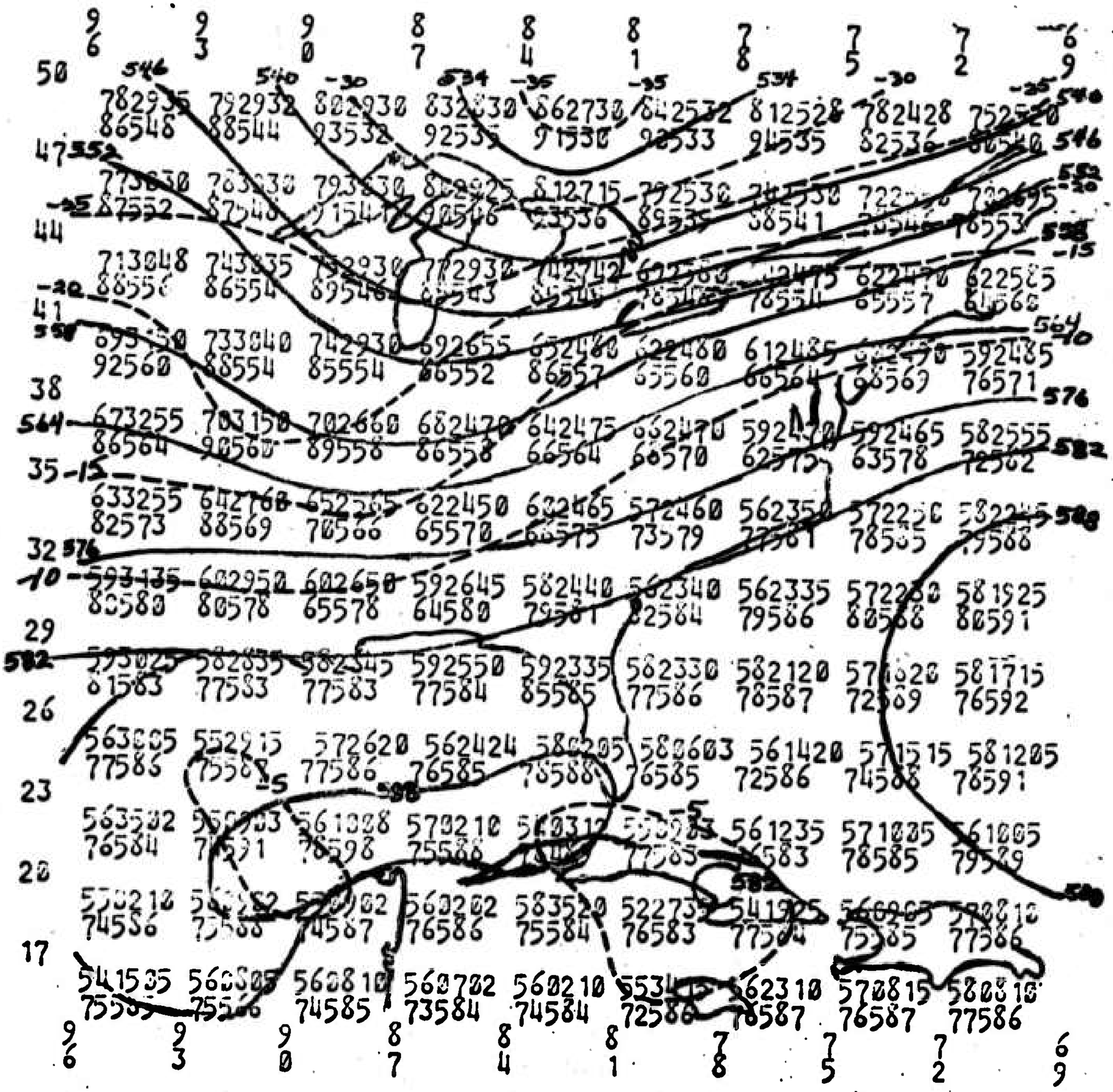


Figure B.12. ... Analysis, Upper Air TELEPLOT.

UPPER AIR TELEPLOT

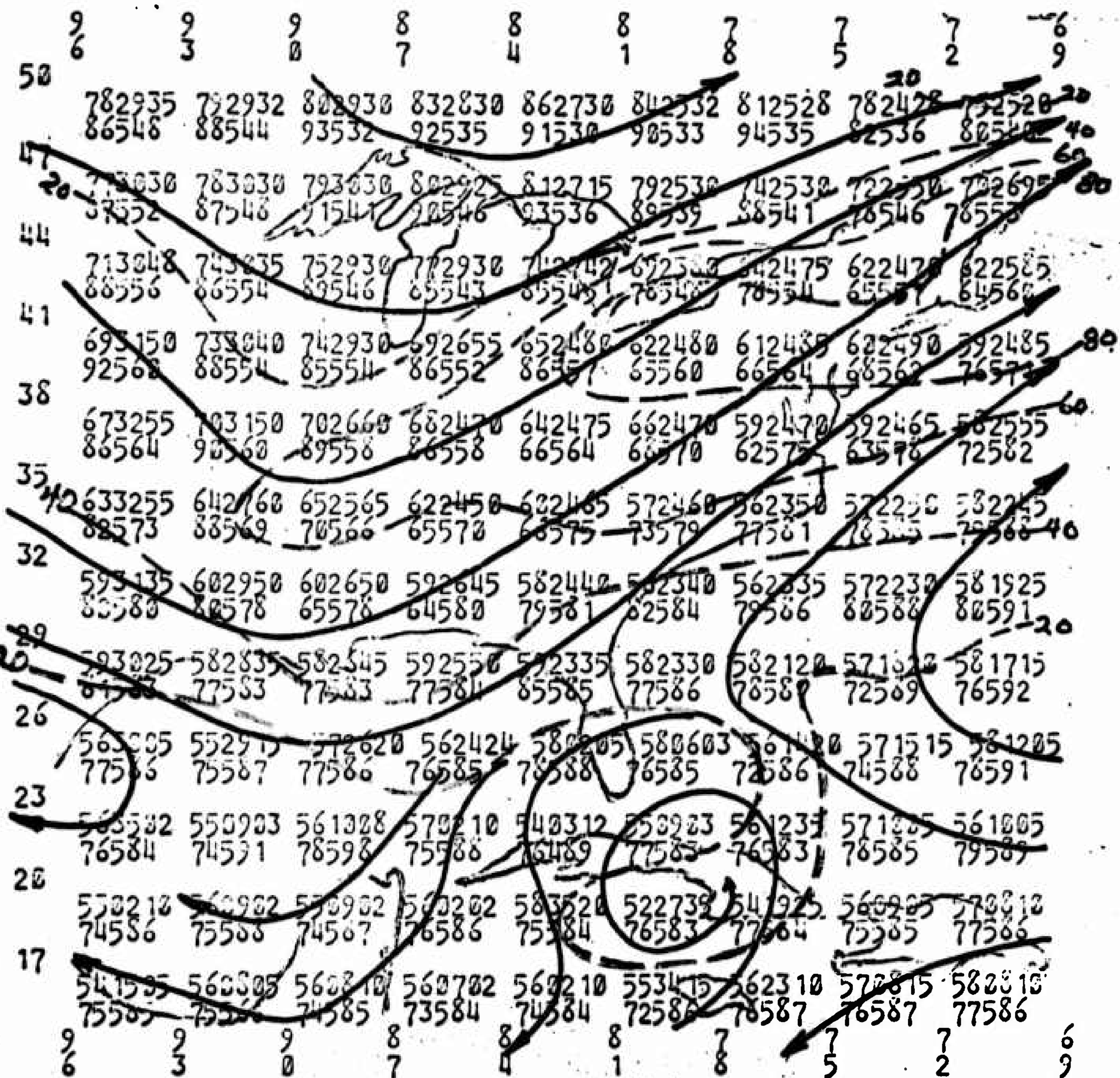


Figure B 1[illegible] [illegible] A[illegible] TELEPLOT.

assigned to each grid square which encloses significant features. The degree of definition is controlled by the grid size. For the purposes of this report, the brightness scale from 1 to 9 (9 is the brightest) will be used.

The weather observer on the hurricane hunter aircraft, in encoding the message, sends only the significant radar scope features in order to minimize communications time. This example is purposely long to show the detail that may be achieved. The hurricane is identified by name, and the position of the center is given in degrees of latitude and longitude, and grid line and column number. The line number is identified, followed by the column number at the start of the first bright area, the brightness code number for each grid square in order, and by the last brightness code number's column number. Subsequent bright areas in the same line are identified by start and stop column numbers, which are included as the first and last number of a series of brightness code numbers.

When the CW message is received from the hurricane hunter aircraft, the analyst at the U. S. Navy Fleet Weather Facility, Jacksonville, Florida would enter the brightness numbers on his Hurricane TELEPLOT Grid A. The result is a TELEPLOT like figure B. 14. This same TELEPLOT could be sent by teletype to all stations, facilities, and ships in the affected or threatened area.

Example Hurricane TELEPLOT CW MESSAGE

HURRICANE ELLA CENTERED 15.2 N 43.7 W TELEPLOT GRID A

COLUMN 21 LINE 11

L2 R20 2233443321 R29 L3 R17 112333577777654
2222 R35 L4 R14 33454333226788887665542222 R38
L5 R11 24456541 R19 R25 678885 R30 R34 5443
3211 R41 L6 R10 23457653 R17 R26 883 R30
R36 3322211 R42 L7 R8 255577632 R16 R27 884

etc.

Figure B.15 is an analysis of the 9, 7, 5 and 3 brightness lines, which is essentially a pseudo iso-echo picture of the hurricane.

8. Miscellaneous TELEPLOTs

As mentioned earlier, the TELEPLOT method has exceptional versatility in transmitting pictorial or graphic data -- not only environmental data but anything from electro-cardiograph traces to engine performance charts. The few examples presented in this report are based upon various fleet and facility requests. The range of applicability is obviously extensive. Other TELEPLOTs, not included in this report, are available at NWRF. Among these are satellite, climatological, ASW, ~~and~~ fleet and research TELEPLOTs, and several adaptations to the specialized requirements of aviation.

HURRICANE TELEPLOT GRID A

```
 12345678901234567890123456789012345678901234567890
1
2                   2233443321
3                11233357777765422222
4             3345433322678887665542222
5           24456541     678885   54433211
6         23457653          883     3322211
7       255577632          884        33322211
8      455776775    7766   3           34332211
9     445578877    7998865              3333221
0     455788      7987777764             2333221
1     455785      789     752              23321
2     45564       78899    4654            223321
3     44544        7788     464             2232
4     445544                464              232
5      455554              45742             22
6       45655           34422               21
7       45775   888    223432
8       478776   8988 232
9        688876   9987
0         8898876  9987
1           899988899887
2            88999998887
3              8888888
4
5
6
7
8
9
0
```

Figure B.14. [illegible] Radar echo brightness estimated by [illegible] aircraft on an increasing scale [illegible]

HURRICANE TELEPLOT GRID A

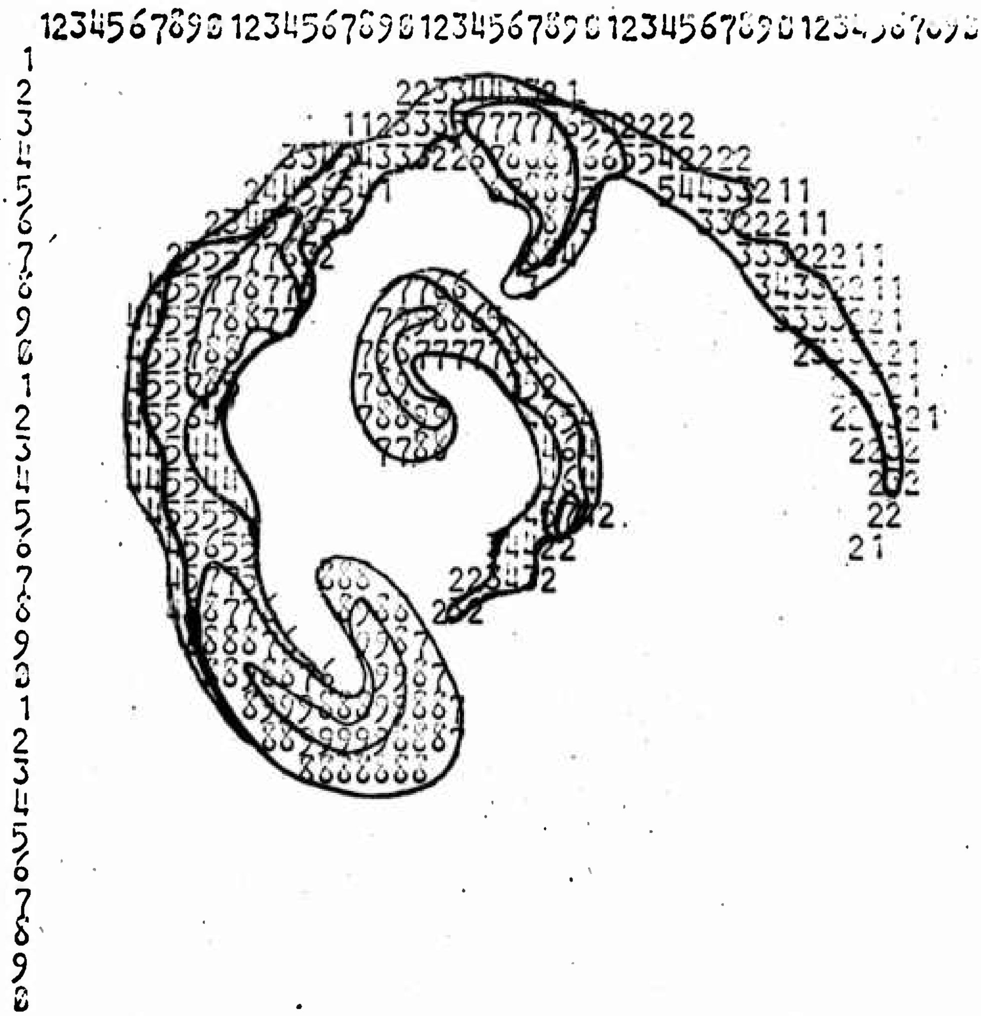


Figure B.1[illegible]. Pa[illegible] A[illegible] of the Hurricane TELEPLOT, figure B.1[illegible].

APPENDIX C

RATTGRAPHICS

Since April 1966 the U. S. Navy Weather Research Facility and the U. S. Navy Fleet Weather Facility have been working jointly on the problems of weather presentation by teletype. In July 1966 the first operational applications of the TELEPLOT method, High Seas and Wind Warnings, were ~~was~~ transmitted to the fleet on an experimental basis under the name of RATTGRAPHICS. The first of these were ~~was~~ prepared by the manual method as outlined in section 3. Since that time, the Fleet Weather Facility has received a digitizer, which simplifies and expedites the preparation of these products. With this new equipment, the capability of data reproduction has been more fully realized. The following series includes the RATTGRAPHICs presently available; however, new products are continuously being evaluated for early addition to this collection.

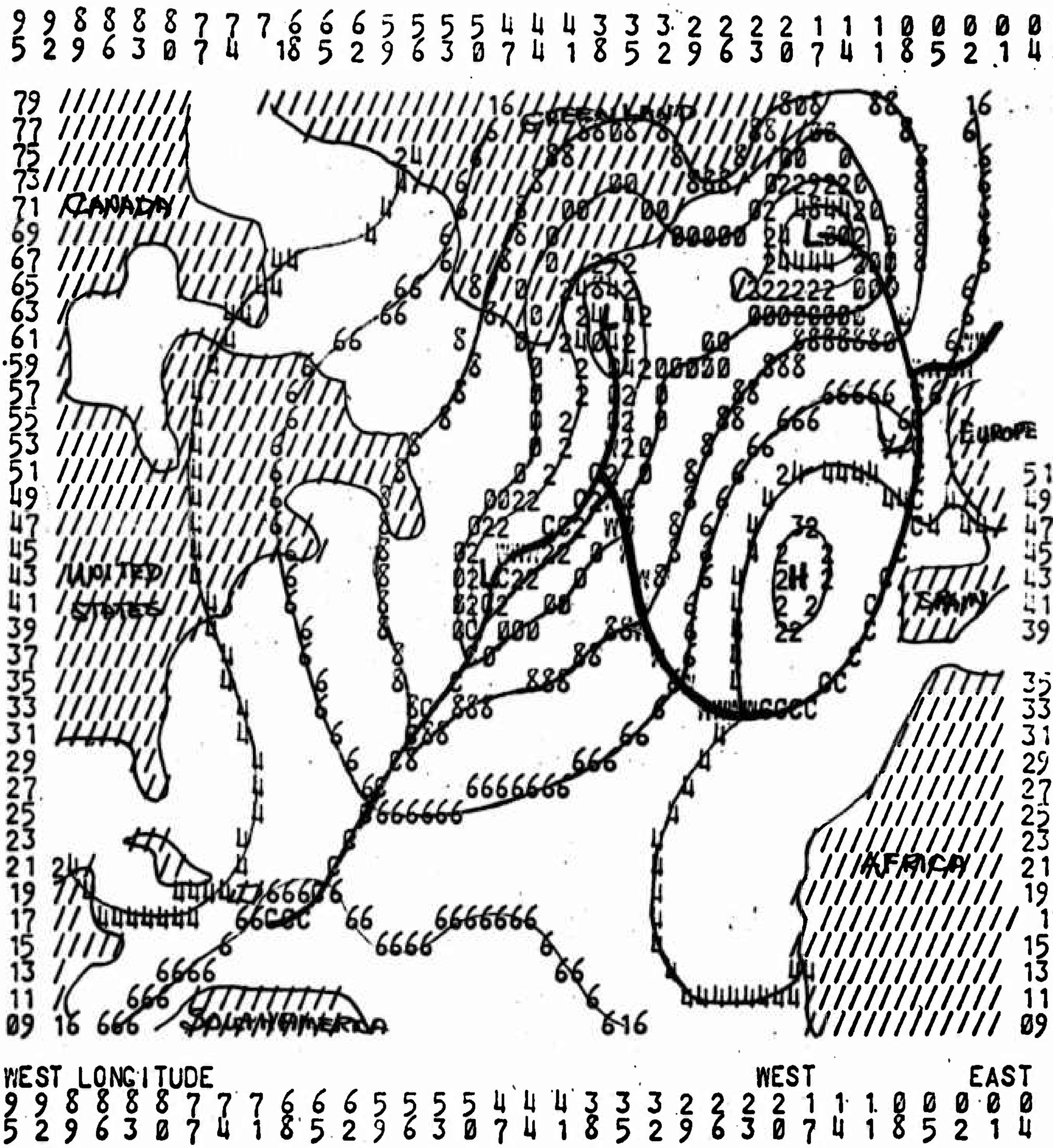


Figure C.1. [illegible] Pressure Pattern and Fronts RATTGRAPHIC

Figure C-2. Analyzed High Seas Warning RATTYGRAPHIC.

23 00Z

UNCLAS

130000Z FLEWEAFAC NORVA NORTH ATLANTIC HIGH SEAS WARNING

1. CODED HIGH SEAS CHART VALID 130000Z

LEGEND

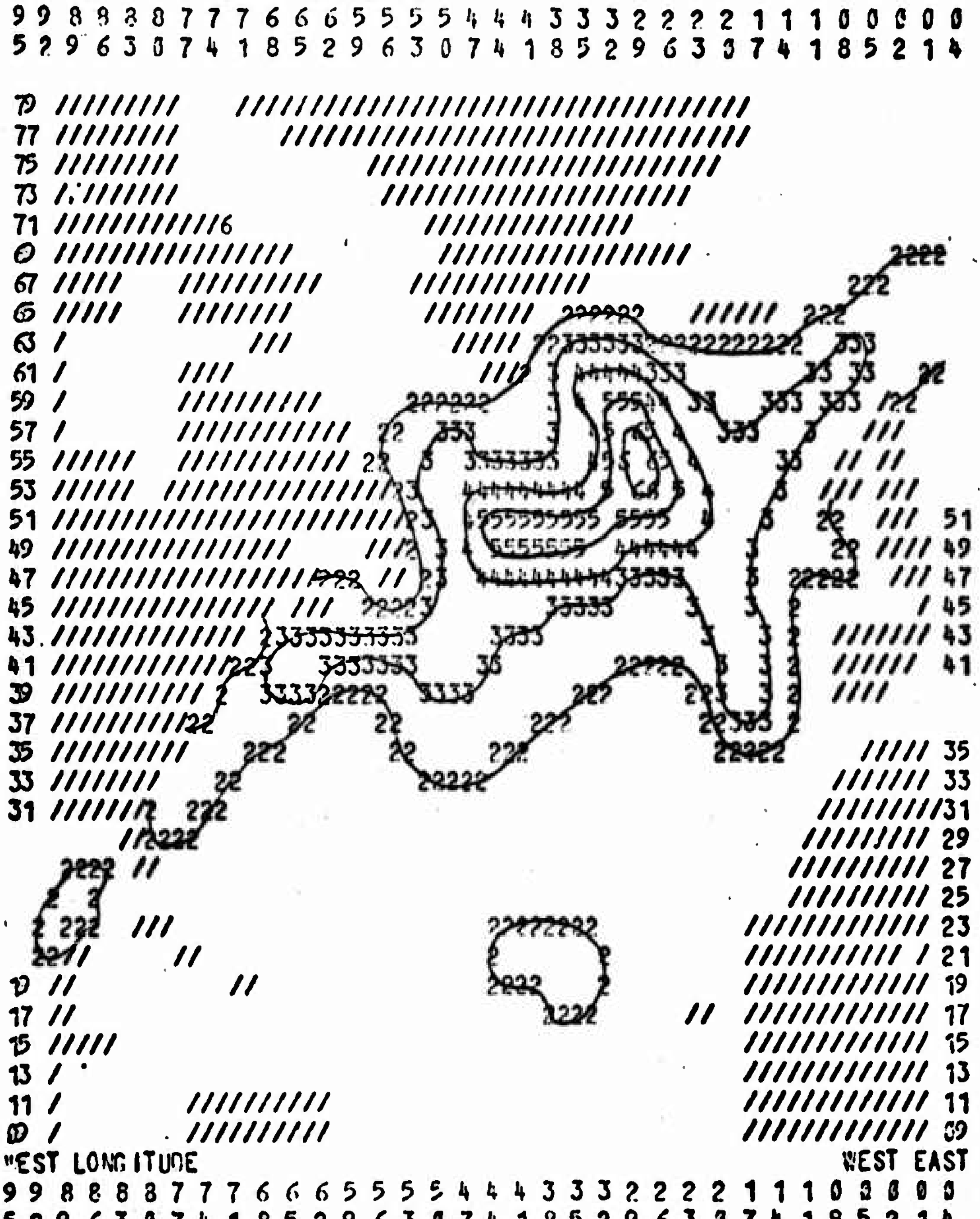
(A) COMBINED SEA HEIGHT (CODED AS SINGLE DIGITS TWO THROUGH NINE) IS GIVEN AT TWO DEGREE LATITUDE AND ONE AND ONE-HALF DEGREE LONGITUDE INTERSECTIONS WHERE OCCURRING.

(B) MULTIPLY CODED DIGIT BY FOUR TO OBTAIN SIGNIFICANT SEA HEIGHT IN FEET.

(C) MULTIPLY CODED DIGIT BY SEVEN TO OBTAIN HIGHEST PROBABLE SEAS.

(D) AREAS OF SEAS EQUAL TO OR GREATER THAN TWELVE FEET ARE ENCLOSED BY CODE DIGIT THREE.

(E) SLANTS DEPICT LAND AREAS.



27 05 43Z

UNCLAS

120600Z FLEWEAFAC NORVA WESTERN NORTH ATLANTIC WIND WARNING

1. PROGNOSTIC CODED WIND SPEED CHART VALID 120600Z

LEGEND

(A) WIND SPEED IN KNOTS (CODED AS SINGLE DIGIT THREE THROUGH NINE) IS GIVEN AT TWO DEGREE LATITUDE AND ONE AND ONE-HALF DEGREE LONGITUDE INTERSECTIONS WHERE OCCURRING.

(B) MULTIPLY CODED DIGIT BY TEN TO OBTAIN WIND SPEED IN KNOTS. E.G. FIGURE 5 INDICATES WINDS OF 50 KNOTS OR GREATER.

(C) SLANTS DEPICT LAND AREAS.

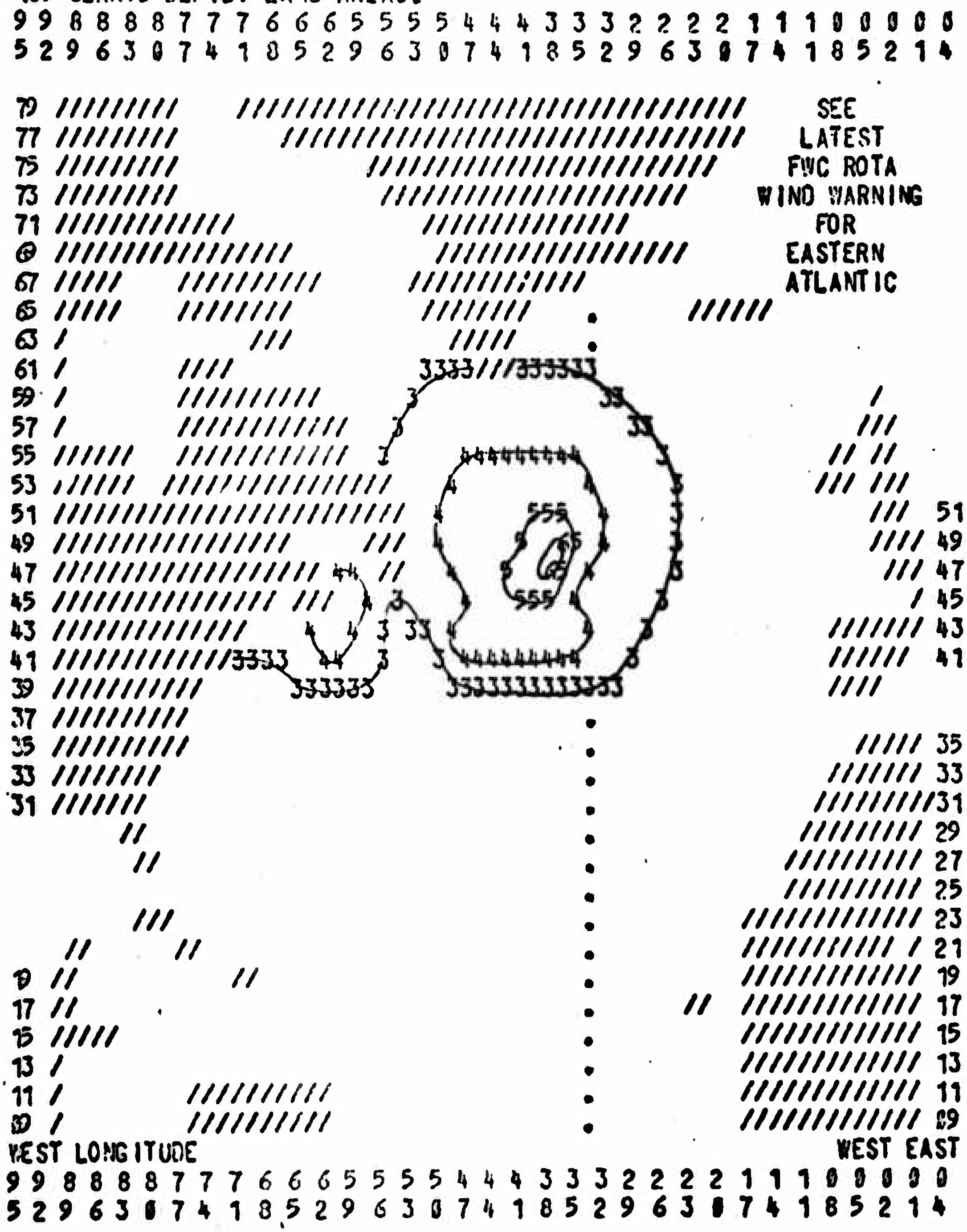


Fig... C... ...RAPHIC

Figure C.4. [illegible] Sea S[illegible] Temperature RATTGRAPHIC

12FEB67 03 11Z

```
UNCLAS E F T O
1. CODED SEA SFC TEMP ANAL 12 FEB 67
LEGEND:
(A) SEA SFC TEMP (CODED AS SINGLE DIGITS ZERO THROUGH NINE)
IS GIVEN AT ONE HALF DEGREE LATITUDE AND LONGITUDE INTERSECTIONS.
(B) MULTIPLY CODED DIGIT BY FIVE AND ADD THIRTY FIVE TO OBTAIN
SEA SFC TEMP IN DEGREES FAHRENHEIT.
(C) CODED FIGURE NINE INDICATES TEMPERATURES EQUAL TO AND GREATER
THAN 80DEGREES FAHRENHEIT.
(D) SLANTS (/) DEPICT A LAND AREA.
(E) BLAND AREAS INDICATE TEMPERATURES LESS THAN 35 DEGREES
FAHRENHEIT.
      7 7 7 7 7 7 6 6 6 6  WEST
      5 4 3 2 1 0 9 8 7 6  LONGITUDE

45N  //////////////////
     ////////////////   //
44N  //////////////0    //
     ////////////000     0
43N  ////////////00   0000
     ////////////000 000000
42N  ////////////000000000//
     /////////0/001212001 12
41N  ////////11001122 1012
     ///1111122 1001222 112
40N  ///1111233321002333223
     //1112133332234443 33
39N  /1112223344445664453
     /1233323345555/5044 43
38N  [illegible]45[illegible]
     [illegible]
37N  [illegible]77777[illegible]
     [illegible]
36N  [illegible]555[illegible]555
     [illegible]55555555555
35N  [illegible]5555555555
     777777[illegible]555[illegible]666666
34N  66666555667766666666
     777766677077766666666
33N  667766667777666667666
     677666667777666776666
32N  677766667776677776666
     667777667766667766666
31N  667777677766677666667
     768766777766776677777
30N  77777777777776667777777
     8777777777777667777776
29N  8887777777777766777776
     8887777777777766777776
28N  887777777777777777777837
     87777777777777777778883
27N  7777777777777777888888
     7778877777777778888877
26N  7728877777777788888777
BT
```

Figure C.[illegible]. Analyzed Sonic Layer Depth RATTGRAPHIC

```
UNCLAS E F T O
1. CODED SONIC LAYER DEPTH ANAL 12 FEB 67
LEGEND:
(A) SONIC LAYER DEPTH (CODED AS SINGLE DIGITS ONE THROUGH NINE)
IS GIVEN AT ONE HALF DEGREE LATITUDE AND LONGITUDE INTERSECTIONS.
(B) MULTIPLY CODED DIGIT BY FIFTY TO OBTAIN LAYER DEPTH IN FEET.
(C) CODED DIGIT NINE REPRESENTS LAYER DEPTH EQUAL TO OR GREATER THAN
450 FEET
(D) BLANK AREAS DEPICT LAYER DEPTHS LESS THAN FIFTY FEET.
(E) SLANTS (/) DEPICT LAND AREA.
      7 7 7 7 7 7 6 6 6 6  WEST
      5 4 3 2 1 0 9 8 7 6  LONGITUDE

45N   ////////////////444
      ////////////////55//
44N   //////////////445885//
      ////////////5578888544
43N   ///////////6888888666
      ///////////5888888866
42N   ////////////688674698
      /////////3/33066334588
41N   ////////3433333346888
      ///334444544456788888
40N   ///4445888888888888888
      //3345888788886788888
39N   /3447788866774478888
      /3577887864444578888
38N   3488668845455546766775
      358888855455544445557
37N   35888885545555555448
      38850785545655544458
36N   37854455580865555454
      35455555589998889999
35N   5455558878999999999
      5554458999999999999
34N   3335899880579999999
      3335999883379999888
33N   3336999863589988788
      3337999851789877888
32N   3333999434445788888
      3333999835658888388
31N   3333899434457888888
      4334838323335667776
30N   4334872222244433333
      4333322222334322224
29N   4443222222244322224
      4442222222224322223
28N   5432222222233322322
      5322222222232223333
27N   5322332222222333333
      5222332222223333332
26N   5224432222223333322
BT
```

APPENDIX D

WORLD METEOROLOGICAL ORGANIZATION CODES

Code 0500

C — *Genus of cloud*

— *Genus of cloud for nephoscopic reports*

— *Genus of cloud penetrated by the aircraft*

C' — *Genus of cloud whose base is below the level of the land station*

Code figure		
0	Cirrus	Ci
1	Cirrocumulus	Cc
2	Cirrostratus	Cs
3	Altocumulus	Ac
4	Altostratus	As
5	Nimbostratus	Ns
6	Stratocumulus	Sc
7	Stratus	St
8	Cumulus.	Cu
9	Cumulonimbus	Cb
/	Cloud not visible owing to darkness, fog, duststorm, sandstorm, or other analogous phenomena	

Code 0509

C_H — *Clouds of the genera Cirrus, Cirrocumulus and Cirrostratus*

Code figure	Technical specifications	Code figure	Non technical specifications
0	No C_H clouds	0	No Cirrus, Cirrocumulus or Cirrostratus
1	Cirrus fibratus, sometimes uncinus, not progressively invading the sky	1	Cirrus in the form of filaments, strands or hooks, not progressively invading the sky
2	Cirrus spissatus, in patches or entangled sheaves, which usually do not increase and sometimes seem to be the remains of the upper part of a Cumulonimbus; or Cirrus castellanus or floccus	2	Dense Cirrus, in patches or entangled sheaves, which usually do not increase and sometimes seem to be the remains of the upper part of a Cumulonimbus; or Cirrus with sproutings in the form of small turrets or battlements, or Cirrus having the appearance of cumuliform tufts
3	Cirrus spissatus cumulonimbogenitus	3	Dense Cirrus, often in the form of an anvil, being the remains of the upper parts of Cumulonimbus
4	Cirrus uncinus or fibratus, or both, progressively invading the sky; they generally thicken as a whole	4	Cirrus in the form of hooks or of filaments, or both, progressively invading the sky; they generally become denser as a whole
5	Cirrus (often in bands) and Cirrostratus, or Cirrostratus alone, progressively invading the sky; they generally thicken as a whole, but the continuous veil does not reach 45 degrees above the horizon	5	Cirrus (often in bands converging towards one point or two opposite points of the horizon) and Cirrostratus, or Cirrostratus alone; in either case, they are progressively invading the sky, and generally growing denser as a whole, but the continuous veil does not reach 45 degrees above the horizon
6	Cirrus (often in bands) and Cirrostratus, or Cirrostratus alone, progressively invading the sky; they generally thicken as a whole; the continuous veil extends more than 45 degrees above the horizon, without the sky being totally covered	6	Cirrus (often in bands converging towards one point or two opposite points of the horizon) and Cirrostratus, or Cirrostratus alone; in either case, they are progressively invading the sky, and generally growing denser as a whole; the continuous veil extends more than 45 degrees above the horizon, without the sky being totally covered
7	Cirrostratus covering the whole sky	7	Veil of Cirrostratus covering the celestial dome

D-2

(*Code 0509 — Continued*)

Code figure	Technical specifications	Code figure	Non technical specifications
8	Cirrostratus not progressively invading the sky and not entirely covering it	8	Cirrostratus not progressively invading the sky and not completely covering the celestial dome
9	Cirrocumulus alone, or Cirrocumulus predominant among the C_H clouds	9	Cirrocumulus alone, or Cirrocumulus accompanied by Cirrus or Cirrostratus, or both, but Cirrocumulus is predominant
/	C_H clouds invisible owing to darkness, fog, blowing dust or sand or other similar phenomena, or because of a continuous layer of lower clouds	/	Cirrus, Cirrocumulus and Cirrostratus invisible owing to darkness, fog, blowing dust or sand or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds

Code 0513

C_L — *Clouds of the genera Stratocumulus, Stratus, Cumulus and Cumulonimbus*

Code figure	Technical specifications	Code figure	Non technical specifications
0	No C_L clouds	0	No Stratocumulus, Stratus, Cumulus or Cumulonimbus
1	Cumulus humilis or Cumulus fractus other than of bad weather,* or both	1	Cumulus with little vertical extent and seemingly flattened, or ragged Cumulus other than of bad weather,* or both
2	Cumulus mediocris or congestus, with or without Cumulus of species fractus or humilis or Stratocumulus, all having their bases at the same level	2	Cumulus of moderate or strong vertical extent, generally with protuberances in the form of domes or towers, either accompanied or not by other Cumulus or by Stratocumulus, all having their bases at the same level
3	Cumulonimbus calvus, with or without Cumulus, Stratocumulus or Stratus	3	Cumulonimbus the summits of which, at least partially, lack sharp outlines, but are neither clearly fibrous (cirriform) nor in the form of an anvil; Cumulus, Stratocumulus or Stratus may also be present
4	Stratocumulus cumulogenitus	4	Stratocumulus formed by the spreading out of Cumulus; Cumulus may also be present
5	Stratocumulus other than Stratocumulus cumulogenitus	5	Stratocumulus not resulting from the spreading out of Cumulus
6	Stratus nebulosus or Stratus fractus other than of bad weather,* or both	6	Stratus in a more or less continuous sheet or layer, or in ragged shreds, or both, but no Stratus fractus of bad weather *
7	Stratus fractus or Cumulus fractus of bad weather,* or both (pannus), usually below Altostratus or Nimbostratus	7	Stratus fractus of bad weather * or Cumulus fractus of bad weather, or both (pannus), usually below Altostratus or Nimbostratus
8	Cumulus and Stratocumulus other than Stratocumulus cumulogenitus, with bases at different levels	8	Cumulus and Stratocumulus other than that formed from the spreading out of Cumulus; the base of the Cumulus is at a different level from that of the Stratocumulus
9	Cumulonimbus capillatus (often with an anvil), with or without Cumulonimbus calvus, Cumulus, Stratocumulus, Stratus or pannus	9	Cumulonimbus, the upper part of which is clearly fibrous (cirriform), often in the form of an anvil; either accompanied or not by Cumulonimbus without anvil or fibrous upper part, by Cumulus, Stratocumulus, Stratus or pannus
/	C_L clouds invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena	/	Stratocumulus, Stratus, Cumulus and Cumulonimbus invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena

* "Bad weather" denotes the conditions which generally exist during precipitation and a short time before and after.

Code 0515

C_M — *Clouds of the genera Altocumulus, Altostratus and Nimbostratus*

Code figure	Technical specifications	Code figure	Non technical specifications
0	No C_M clouds	0	No Altocumulus, Altostratus or Nimbostratus
1	Altostratus translucidus	1	Altostratus, the greater part of which is semi-transparent; through this part the sun or moon may be weakly visible, as through ground glass
2	Altostratus opacus or Nimbostratus	2	Altostratus, the greater part of which is sufficiently dense to hide the sun or moon, or Nimbostratus
3	Altocumulus translucidus at a single level	3	Altocumulus, the greater part of which is semi-transparent; the various elements of the cloud change only slowly and are all at a single level
4	Patches (often lenticular) of Altocumulus translucidus, continually changing and occurring at one or more levels	4	Patches (often in the form of almonds or fishes) of Altocumulus, the greater part of which is semi-transparent; the clouds occur at one or more levels and the elements are continually changing in appearance
5	Altocumulus translucidus in bands, or one or more layers of Altocumulus translucidus or opacus, progressively invading the sky; these Altocumulus clouds generally thicken as a whole	5	Semi-transparent Altocumulus in bands, or Altocumulus in one or more fairly continuous layers (semi-transparent or opaque), progressively invading the sky; these Altocumulus clouds generally thicken as a whole
6	Altocumulus cumulogenitus (or cumulonimbogenitus)	6	Altocumulus resulting from the spreading out of Cumulus (or Cumulonimbus)
7	Altocumulus translucidus or opacus in two or more layers, or Altocumulus opacus in a single layer, not progressively invading the sky, or Altocumulus with Altostratus or Nimbostratus	7	Altocumulus in two or more layers, usually opaque in places, and not progressively invading the sky; or opaque layer of Altocumulus, not progressively invading the sky; or Altocumulus together with Altostratus or Nimbostratus
8	Altocumulus castellanus or floccus	8	Altocumulus with sproutings in the form of small towers or battlements, or Altocumulus having the appearance of cumuliform tufts
9	Altocumulus of a chaotic sky, generally at several levels	9	Altocumulus of a chaotic sky, generally at several levels
/	C_M clouds invisible owing to darkness, fog, blowing dust or sand or other similar phenomena, or because of a continuous layer of lower clouds	/	Altocumulus, Altostratus and Nimbostratus invisible owing to darkness, fog, blowing dust or sand or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds

Code 0663

c_2 — *Description of kind of ice*

Code figure	
0	No ice (0 may be used to report *ice blink* and then a direction must be reported)
1	New ice
2	Fast ice
3	Pack ice/drift ice
4	Packed (compact) slush or sludge
5	Shore lead
6	Heavy fast ice
7	Heavy pack ice/drift ice
8	Hummocked ice
9	Icebergs *

* Icebergs can also be reported in plain language.

Code 0885

d_wd_w — *Direction, in tens of degrees, from which waves are coming*

Code figure		Code figure	
00	Calm (no waves)	22	215° – 224°
01	5° – 14°	23	225° – 234°
02	15° – 24°	24	235° – 244°
03	25° – 34°	25	245° – 254°
04	35° – 44°	26	255° – 264°
05	45° – 54°	27	265° – 274°
06	55° – 64°	28	275° – 284°
07	65° – 74°	29	285° – 294°
08	75° – 84°	30	295° – 304°
09	85° – 94°	31	305° – 314°
10	95° – 104°	32	315° – 324°
11	105° – 114°	33	325° – 334°
12	115° – 124°	34	335° – 344°
13	125° – 134°	35	345° – 354°
14	135° – 144°	36	355° – 4°
15	145° – 154°		
16	155° – 164°	49	Waves confused, direction indeterminate (waves equal to or less than 4¾ metres)
17	165° – 174°		
18	175° – 184°		
19	185° – 194°	99	Waves confused, direction indeterminate (waves greater than 4¾ metres)
20	195° – 204°		
21	205° – 214°		

Code 0900

E — *State of the ground*

Code figure	
0	Surface of ground dry (no appreciable amount of dust or loose sand)
1	Surface of ground moist
2	Surface of ground wet (standing water in small or large pools on surface)
3	Surface of ground frozen
4	Glaze or ice on ground, but no snow or melting snow
5	Snow or melting snow (with or without ice) covering less than one-half of the ground
6	Snow or melting snow (with or without ice) covering more than one-half of the ground but ground not completely covered
7	Snow or melting snow (with or without ice) covering ground completely
8	Loose dry snow, dust or sand covering more than one-half of ground (but not completely)
9	Loose dry snow, dust or sand covering ground completely

Notes:

(1) Where dust or sand is reported and the temperature is below 0° C, the word DUST or SAND is added at the end of the report.

(2) The definitions in the code for E for numbers 0 to 3 apply to representative bare ground and numbers 4 to 9 to an open representative area.

(3) In all instances the highest code figures applicable are to be reported.

Code 1555

H_w — *Height of the waves*

Code figure	
0	Less than 1/4 m
1	1/2 m
2	1 m
3	1 1/2 m
4	2 m
5	2 1/2 m
6	3 m
7	3 1/2 m
8	4 m
9	4 1/2 m
/	Height not determined

Code figure	If 50 is added to $d_w d_w$
0	5 m
1	5 1/2 m
2	6 m
3	6 1/2 m
4	7 m
5	7 1/2 m
6	8 m
7	8 1/2 m
8	9 m
9	9 1/2 m

Notes:

(1) Each code figure provides for reporting a range of heights. For example: 1 = 1/4 m to 3/4 m; 5 = 2 1/4 m to 2 3/4 m; 9 = 4 1/4 m to 4 3/4 m, etc.

(2) If a wave height comes exactly midway between the heights corresponding to two code figures, the lower code figure is reported; e.g. a height of 2 3/4 m is reported by code figure 5.

(3) In aeronautical forecast codes, only the left-hand table is to be used and code figure 9 has the meaning: 4 1/4 m or more.

(4) The average value of the wave height (vertical distance between trough and crest) is reported, as obtained from the larger well formed waves of the wave system being observed.

Code 1600

h — *Height, above ground, of the base of the cloud*

Code figure	
0	0 to 50 m
1	50 to 100 m
2	100 to 200 m
3	200 to 300 m
4	300 to 600 m
5	600 to 1,000 m
6	1,000 to 1,500 m
7	1,500 to 2,000 m
8	2,000 to 2,500 m
9	2,500 m or more, or no clouds
/	Height of base of cloud not known *or* base of clouds at a level lower and tops at a level higher than that of the station;

Notes:

(1) A height exactly equal to one of the values at the ends of the ranges is to be coded in the higher range; e.g. a height of 600 m is reported by code figure 5.

(2) The term "height above ground" is considered as being the height above the official aerodrome elevation or above station level at a non-aerodrome station.

Code 1900

J — *Aircraft icing and turbulence*

Code figure		
0	No specification	
1	No icing and no turbulence	
2	Slight turbulence	no icing
3	Moderate turbulence	no icing
4	Heavy turbulence	
5	Slight icing	no turbulence or slight turbulence
6	Moderate icing	no turbulence or slight turbulence
7	Heavy icing	no turbulence or slight turbulence
8	Slight icing	moderate or heavy turbulence
9	Moderate or heavy icing	moderate or heavy turbulence

Code 2700

N	— *The fraction of the celestial dome covered by cloud*
N_h	— *The fraction of the celestial dome covered by all the C_L-cloud(s) present and if no C_L-cloud is present, that fraction covered by all the C_M-cloud(s) present*
N_s	— *Amount of individual cloud layer or mass, of genus C*
N′	— *Amount of cloud whose base is below the level of the land station*

Code figure		
0	0	0
1	1 okta or less, but not zero	$^1/_{10}$ or less, but not zero
2	2 oktas	$^2/_{10}$ – $^3/_{10}$
3	3 oktas	$^4/_{10}$
4	4 oktas	$^5/_{10}$
5	5 oktas	$^6/_{10}$
6	6 oktas	$^7/_{10}$ – $^8/_{10}$
7	7 oktas or more, but not 8 oktas	$^9/_{10}$ or more, but not $^{10}/_{10}$
8	8 oktas	$^{10}/_{10}$
9	Sky obscured, or cloud amount cannot be estimated	

Code 3155

P_w — *Period of waves*

Code figure		Code figure	
2	5 seconds or less	8	16 or 17 seconds
3	6 or 7 seconds	9	18 or 19 seconds
4	8 or 9 seconds	0	20 or 21 seconds
5	10 or 11 seconds	1	Over 21 seconds
6	12 or 13 seconds	/	Calm, or period not determined
7	14 or 15 seconds		

Notes:

(1) The period of the waves is the time between the passage of two successive wave crests past a fixed point (it is equal to the wave length divided by the wave speed).

(2) The average value of the wave period is reported, as obtained from the larger well-formed waves of the wave system being observed.

Code 4300

V — *Visibility at surface*

Code figure	
0	Less than 50 metres
1	50–200 metres
2	200–500 metres
3	500–1,000 metres
4	1– 2 km
5	2– 4 km
6	4–10 km
7	10–20 km
8	20–50 km
9	50 km or more

Code 4451

v_s — *Ship's average speed made good during the three hours preceding the time of observation*

Code figure		
0	0 nautical mile per hour	0 kilometre per hour
1	1 – 3 nautical miles per hour	1 – 6 kilometres per hour
2	4 – 6 nautical miles per hour	7 – 12 kilometres per hour
3	7 – 9 nautical miles per hour	13 – 17 kilometres per hour
4	10 – 12 nautical miles per hour	18 – 23 kilometres per hour
5	13 – 15 nautical miles per hour	24 – 28 kilometres per hour
6	16 – 18 nautical miles per hour	29 – 34 kilometres per hour
7	19 – 21 nautical miles per hour	35 – 39 kilometres per hour
8	22 – 24 nautical miles per hour	40 – 44 kilometres per hour
9	Over 24 nautical miles per hour	Over 44 kilometres per hour

Code 4562

W_1 — *Forecast weather*

Code figure	
0	Moderate or good visibility (greater than 5 km)
1	Risk of accumulation of ice on superstructures (air temperature between 0 and –5° C)
2	Strong risk of accumulation of ice on superstructures (air temperature below –5° C)
3	Mist (Visibility 1–5 km)
4	Fog (Visibility less than 1 km)
5	Drizzle
6	Rain
7	Snow or rain and snow
8	Squally weather with or without showers
9	Thunderstorms

Code 4647

w_2 — *Type of precipitation falling in the flight zone*

Code figure	
0	Undefined precipitation
1	Drizzle
2	Rain
3	Snow
4	Wet snow
5	Rain showers
6	Snow showers
7	Snow pellets, hail
8	Rain and thunder
9	Hail (snow pellets, snow) and thunder

Code 4537

w_1w_1 — *Forecast weather at surface* (to be used in aeronautical forecast codes)

Code figure	
00	No cloud
01	Clouds dissipating
02	State of sky not changing.
03	Clouds increasing
04	Smoke
05	Haze
06	Widespread dust* in suspension
07	Dust / sand raised by wind
08	Well developed dust whirls or sand whirls
09	—
10	Mist
11	Shallow fog or ice fog (in patches)
12	Shallow fog or ice fog (continuous)
13	Lightning
14	—
15	Precipitation within sight, distant from the station
16	Precipitation within sight, near to the station
17	Thunderstorm, but no precipitation
18	Squall(s)
19	Funnel cloud(s)
20–29	—
30	—
31	Slight or moderate duststorm or sandstorm
32	—
33	—
34	Severe duststorm or sandstorm
35	—
36	Slight or moderate drifting snow } low (below eye level)
37	Heavy drifting snow } low (below eye level)
38	Slight or moderate blowing snow } high (above eye level)
39	Heavy blowing snow } high (above eye level)
40	Fog or ice fog at distance
41	Fog or ice fog in patches
42	Fog or ice fog, sky visible } thinning
43	Fog or ice fog, sky invisible } thinning
44	Fog or ice fog, sky visible
45	Fog or ice fog, sky invisible
46	Fog or ice fog, sky visible } thickening
47	Fog or ice fog, sky invisible } thickening
48	Fog, depositing rime, sky visible
49	Fog, depositing rime, sky invisible
50	Drizzle, slight, intermittent
51	Drizzle, slight, continuous
52	Drizzle, moderate, intermittent
53	Drizzle, moderate, continuous
54	Drizzle, heavy (dense), intermittent
55	Drizzle, heavy (dense), continuous
56	Drizzle, slight, freezing
57	Drizzle, moderate or heavy (dense), freezing
58	Drizzle and rain, slight
59	Drizzle and rain, moderate or heavy
60	Rain, slight, intermittent
61	Rain, slight, continuous
62	Rain, moderate, intermittent
63	Rain, moderate, continuous
64	Rain, heavy, intermittent
65	Rain, heavy, continuous
66	Rain, slight, freezing
67	Rain, moderate or heavy, freezing
68	Rain or drizzle and snow, slight
69	Rain or drizzle and snow, moderate or heavy

* Dust haze.

D-9

(Continued)

W_1W_1

(Code 4687 — Continued)

70	Snow, slight, intermittent	
71	Snow, slight, continuous	
72	Snow, moderate, intermittent	
73	Snow, moderate, continuous	
74	Snow, heavy, intermittent	
75	Snow, heavy, continuous	
76	Ice prisms	
77	Snow grains	
78	—	
79	Ice pellets type (a)	
80	Rain shower(s), slight	
81	Rain shower(s), moderate or heavy	
82	Rain shower(s), violent	
83	Shower(s) of rain and snow, slight	
84	Shower(s) of rain and snow, moderate or heavy	
85	Snow shower(s), slight	
86	Snow shower(s), moderate or heavy	
87	Shower(s) of snow pellets or ice pellets type (b), with or without rain or rain and snow mixed	– slight
88		– moderate or heavy
89	Shower(s) of hail, with or without rain or rain and snow mixed, not associated with thunder	– slight
90		– moderate or heavy
91	—	
92	—	
93	—	
94	—	
95	Thunderstorm, slight or moderate, with rain or snow	
96	Thunderstorm, slight or moderate, with hail	
97	Thunderstorm, heavy, with rain or snow	
98	Thunderstorm combined with duststorm or sandstorm	
99	Thunderstorm, heavy, with hail	